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VAJIRAM & RAVI

GENERAL STUDIES
SCIENCE & TECHNOLOGY

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CHAPTER – 1

SCIENCE AND TECHNOLOGY IN INDIA

DEVELOPMENTS IN SCIENCE AND TECHNOLOGY

Science & Technology (S&T) has always been an integral part of the Indian culture. The contributions made by the scholar-scientists Aryabhatta, Bhaskara, Brahmagupta, Dhanvantari and Nagarjuna, to name a few, to the fields of mathematics, astronomy, medicine and chemistry during the ancient times are legendary and invaluable not only to Indian S&T but also to the knowledge base of the humanity at large. The astronomical observations at Jaipur and New Delhi and the Ashoka Pillar in New Delhi stand as living testimonies to the high standards of Indian capabilities. The dawn of the present century witnessed great strides made by Indian scientists like Srinivasa Ramanujan, J.C. Bose, P.C. Ray, Meghnad Saha, C.V. Raman, S.N. Bose, Birbal Sahni, P.C. Mahalanobis and M. Visvesvaraya, who have left indelible imprints on the world S&T scene.

The innate ability to perform creatively in science came to be backed with an institutional set-up and strong state support after country's independence in 1947. Since then, the Government of India has spared no effort to establish a modern S&T organisation in the country. India's first Prime Minister Pandit Jawaharlal Nehru gave whole-hearted support to a concerted programme for the promotion of S&T in the country. As a result, many new S&T departments and laboratories were set up and the pursuance of scientific research started in an organised manner. Jawaharlal Nehru firmly believed that Science and Technology can be the twin tools that would help bring about social equity and economic development to enable India join the mainstream of the world community. This conviction was reflected in the Scientific Policy Resolution (SPR) of 1958, the aim of which was "to foster, promote and sustain the cultivation of sciences and scientific research in the country and to secure for the people all the benefits that can accrue from the acquisition and application of scientific knowledge".

With this in view, several departments were set up by the government with specific objectives which at once met the immediate social needs even as they allowed the country to leap-frog into the modern high-tech world. The departments of Atomic Energy, Science and Technology, and Space were thus among the first S&T departments in the country with the Prime Minister himself taking the reins. Industrialisation of the country, according to the founding fathers of modern India, was essential for improving the quality of life. Consequently, the Council of Scientific and Industrial Research (CSIR) expanded with the establishment of various institutions dedicated to the development of specific industries.

As the economic development of the country at that time had not reached a stage where the private sector could play a leading role in the S&T development, the Government took this task upon itself and provided the initial momentum. This has resulted in a broad-based and extensive S&T network.

The S&T departments functioning under the auspices of Central Government are: Department of Science and Technology (DST), Department of Scientific & Industrial Research (DSIR), Department of Atomic Energy (DAE), Department of Space (DoS), Department of Biotechnology (DBT) and Department of Ocean Development (DOD).

Department of Science and Technology (DST) is primarily entrusted with the responsibility of formulation of S&T policies and their implementation, identification and promotion of thrust areas of research in different sectors of S&T; international collaboration, promotion of science & society programmes and coordination of S&T activities in the country.

The **Council of Scientific and Industrial Research (CSIR)**, with its 40 institutes dedicated to research and development in well defined areas and around 100 field stations, is the major organisation under DSIR. Among the other programmes of DSIR are: support to R&D by industry, programmes aimed at technological self-reliance, schemes to enhance efficacy of transfer of technology and a National Information System for Science and Technology (NISSAT).

Department of Atomic Energy (DAE), which is committed to peaceful uses of atomic energy, is mainly engaged in establishing production of safe, economical nuclear power, using country's resources of uranium and thorium. It also extends non-electricity applications of nuclear energy in agriculture, healthcare and industry to improve the quality of life. It builds research reactors and develops technologies related to accelerators and lasers, and supports basic research in areas related to nuclear energy and other frontier areas of science, through its well equipped multi-disciplinary R&D Centres.

Department of Space (DoS) operates through a major set-up, the Indian Space Research Organisation (ISRO), which is responsible for planning and executing a viable space programme to develop satellites and launch systems and provide space-based services in the areas of communication, meteorology, resources survey, management and sustainable development.

Department of Biotechnology (DBT) is primarily responsible for identifying and supporting specific R&D programmes in biotechnology and biotechnology-related product manufacture. It also supports training of young scientists in the field of biotechnology at various universities and institutes.

Department of Ocean Development (DOD) concerns itself with the task of establishing policies for marine R&D, survey of living and non-living resources of EEZ and continental shelf of the country, exploration of deep seabed mining, harnessing wave energy and consolidation of Antarctic research.

Among the S&T organisation associated with other Central Government Ministries, Defence Research & Development Organisation (DRDO) under the Ministry of Defence, Indian Council of Agricultural Research (ICAR) under the Ministry of Agriculture and Indian Council of Medical Research (ICMR) under the Ministry of Health & Family Welfare have large R&D infrastructure.

In addition to R&D establishments, the other major body pursuing S&T activities in India is the country's vast university system.

POLICY DOCUMENTS

1. SCIENTIFIC POLICY RESOLUTION 1958

Through the Scientific Policy resolution of 1958 was aimed:

- to foster, promote, and sustain the cultivation of science, and scientific research in all its aspects - pure, applied, and educational;
- to ensure an adequate supply of research scientists of the highest quality, and to recognize their work as an important component of the strength of the nation;
- to encourage, and initiate programmes for the training of scientific and technical personnel, on a scale adequate to fulfil the country's needs in science and education, agriculture and industry, and defence;
- to ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity;
- to encourage individual initiative for the acquisition and dissemination of knowledge, and for the discovery of new knowledge, in an atmosphere of academic freedom;
- and, in general, to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge.

The scientific policy resolution of 1958 served as the basic guidelines for future policies and development in S&T in India.

2. TECHNOLOGY POLICY STATEMENT 1983

The then PM Smt. Indira Gandhi announced in 1983 the Technology policy of the Government of India. The basic objectives of the Technology Policy will be the development of indigenous technology and efficient absorption and adaptation of imported technology appropriate to national priorities and resources.

3. SCIENCE AND TECHNOLOGY POLICY 2003

Recognizing the changing context of the scientific enterprise, and to meet the national needs in the new era of globalisation, Government brought in Science and Technology Policy 2003 with the following objectives:

- To integrate science and technology with all spheres of national activity.
- To ensure food, agricultural, nutritional, environmental, water, health and energy security of the people on a sustainable basis.
- To mount a direct and sustained effort on the alleviation of poverty and enhancing livelihood security by using scientific and technological capabilities.
- To vigorously foster scientific research in universities and other academic, scientific and engineering institutions; and attract the brightest young people to careers in science and technology
- To promote the empowerment of women in all science and technology activities and ensure their full and equal participation.
- To accomplish national strategic and security-related objectives, by using the latest advances in science and technology.
- To establish an Intellectual Property Rights (IPR) regime which maximises the incentives for the generation and protection of intellectual property by all types of inventors.

- To ensure, in an era in which information is key to the development of science and technology, that all efforts are made to have high-speed access to information, both in quality and quantity, at affordable costs

SCIENCE AND TECHNOLOGY DURING FIVE YEAR PLANS

The five year planning on science and technology aimed to foster, promote and sustain the cultivation of the sciences and scientific research and to encourage individual for dissemination of scientific knowledge and above all to secure for the people of the country all benefits that accrue from the acquisition and application of scientific knowledge.

The focus of five year plans on science and technology were on the needs of the times and continuously evolving. The **First Plan** aimed at the setting up of new national laboratories and research institutes, training the personnel for manning the research institutes and running industries. The **Second Plan** focused on generating scientific manpower in sufficient. The **Seventh plan** recognised new thrust areas in S&T emerging on the world scene, such as micro- electronics, informatics, telemetric, robotics, biotechnology, material science, instrumentation etc. The **eighth plan** sought to integrate science and technology with socio-economic sectors and more particularly rural areas to meet the basic needs of water, nutrition, health and sanitation, shelter, energy, education and employment. The **ninth plan** emphasized on self-reliance due to growing global restrictions on high-technology movement. The **eleventh plan** envisaged the formulation of a National Innovation Policy to encourage competition among enterprise and greater diffusion of knowledge. Other proposals include the Council for Advancement of People's Action and Rural Technology (CAPART) to become an effective link between technology generation centres and various ministries for dissemination and propagation of technology packages through employment generation and capacity building schemes. Despite much progress, a very large part of Indian population continued to be excluded from the benefits of S&T applications. The **twelfth plan** aimed to overcome this exclusion if the goal of inclusive development in the Decade of Innovation has to be met. It dealth with inclusive health; biodiversity based knowledge systems and grassroots innovations; linking modern S&T with traditional arts and other artisanal goods; sustainable land use and climate change etc.

SCIENCE, TECHNOLOGY AND INNOVATION POLICY 2013

The then Prime Minister Dr. Manmohan Singh, unveiled the Science, Technology and Innovation Policy (STI) 2013 at the Centenary session of the Indian Science Congress at Kolkata.

The STI Policy seeks to send a signal to the Indian scientific community, both in the private and public domain, that **science, technology and innovation should focus on faster, sustainable and inclusive development of the people**. The policy seeks to focus on both **STI for people and people for STI**. A Strong and viable Science, Research and Innovation system for High Technology led path for India (**SRISHTI**) are the goal for the STI policy.

The Key features of the STI policy 2013 are

- Making careers in science, research and innovation attractive enough for talented and bright minds.
- Establishing world class infrastructure for R&D for gaining global leadership in some select frontier areas of science.
- Positioning India among the top five global scientific powers by 2020(by increasing the share of global scientific publications from 3.5% to over 7% and quadrupling the number of papers in top 1% journals from the current levels).
- Linking contributions of Science Research and innovation system with the inclusive economic growth agenda and combining priorities of excellence and relevance.
- Creating an environment for enhanced private sector participation in R&D.
- Seeking S&T based high risk innovation through new mechanisms.

ASPIRATIONS OF THE POLICY

- Raising Gross Expenditure in Research and Development (GERD) to 2% from the present 1% of the GDP in this decade by encouraging enhanced private sector contribution.
- Increasing the number of Full Time Equivalent (FTE) of R&D personnel in India by at least 66% of the present strength in 5 years.
- Increasing accessibility, availability and affordability of innovations, especially for women, differently-abled and disadvantaged sections of society.

APPLICATIONS AND EFFECTS OF S&T

If Science refers to the knowledge of matter, space, energy and the various phenomena associated with them, Technology is the systematic application of science to obtain practical value or utility that is helpful in our everyday life. Science and technology has made a phenomenal impact in shaping and altering the lifestyle of the man. The understanding and developing of scientific principles by scientists has led to their large scale application in a variety of fields. Technological developments have found useful applications in health sector; have enhanced the agricultural yield; have been profitably adopted to industrial development and have played an important role in various other crucial fields like defence, communication, energy, environment protection etc.

The impact of the application of scientific and technological developments in our country is seen in the transformation of subsistence agriculture into commercial agriculture; eradication of killer diseases like plague and smallpox and control over many other diseases; establishment and rapid development of an industrial base, development of indigenous capabilities in critical areas of defence, space research, atomic energy etc. and developments in fast emerging hi-tech areas like electronics, communications, oceanography, information technology etc.

Despite all these developments and advancements, a lot still remains to be done. If India has to really forge ahead as a super power in the coming decades, Science and technology must play a pivotal role in all the important tasks that lie ahead of us. Hence the deployment of Science and technology as an effective instrument of growth and change becomes an imperative strategy.

www.upscmaterials.org

Indeed the spectacular achievements in Science and technology have brought about unprecedented economic growth and social transformation in the industrialised countries and this has led to the creation of the favourable climate for Science and technology being made a part of the national endeavour in developing countries as well. It has become necessary for them to harness their scientific and technological efforts to achieve their goals. India too has followed a conscious policy for the development of Science and technology for solving her national problems.

ROLE OF S&T IN SOCIO – ECONOMIC DEVELOPMENT

Ministry of S&T and the other scientific departments have also been working towards evolving and promoting useful applications of S&T in socio-economic development of the nation in general and of the weaker sections of the society in particular. The significant achievements have been –

1. **Natural Resource Management:** National Resource data management system has been devised to evolve a scientific methodology for collection, collation, dissemination and utilization of data on natural resources in a given region.
2. **Space:** The department of space has utilized its expertise in space S&T for socio-economic development in a wide variety of ways – from remote sensing to disaster management, from meteorology to broadcasting, from agro – climatic mapping to natural resources prospecting and from distance education to telemedicine among other.
3. **Atomic Energy:** The department of atomic energy has applied S&T knowledge in socio-economic development through applications like power generation, water purification, nuclear medicine, preservation of agricultural produce and food products etc.
4. **Biotechnology:** The department of biotechnology has developed useful applications of science in areas like development of high yielding crop varieties; genetic improvement of livestock; health care development of diagnostic kits, vaccines, antibiotics etc; development of bio-fertilizers and bio-pesticides to improve agricultural productivity, development of bio agents for pollution management etc.
5. **Eco-friendly technology:** Development of eco-friendly, clean technologies as well as the damage controlling clean-up technologies has played a multi-dimensional role in ensuring good health, sustainable resources and mitigations of environmental hazards.
6. **S&T for socio-economic development:** The programmes for poverty alleviation, rural development, employment generation, upliftment of weaker sections and agricultural productivity enhancement are all inter related and overlapping and S&T has played a very vital role in making them a success. Programmes like –
   - a. Generating technologies for non-traditional occupations like aquaculture, horticulture, manufacturing in small scale/cottage industries etc.
   - b. Technologies for conservation of local resources through training in soil and water conservation technologies, water harvesting technologies etc.
   - c. Development of non-conventional energy sources like biogas, solar cookers etc to improve the quality of life of the people.

d. Improvement of income generation in traditional as well as non – traditional occupations e.g. power looms for faster and easier weaving; training in vegetable dyeing and printing etc.

e. Making use of new knowledge in medical sciences in all aspects of health and family welfare.

Thus, S&T has played a very important role in the socio-economic development of the country.

ACHIEVEMENTS OF INDIA IN SCIENCE AND TECHNOLOGY

ATOMIC ENERGY

The prime objective of India's nuclear energy program is the development and use of nuclear energy for peaceful purposes such as power generation, applications in agriculture, medicine, industry, research and other areas.

India is today recognized as one of the countries, most advanced in nuclear technology including production of source materials. The country is self-reliant and has mastered the expertise covering the complete nuclear cycle - from exploration and mining to power generation and waste management.

SPACE

The Indian Space Research Organization (ISRO), under the Department of Space (DOS), is responsible for research, development and operationalisation of space systems in the areas of satellite communications, remote sensing for resource survey, environmental monitoring, meteorological services etc. India is the only third world country to develop its own remote sensing satellite.

India joined a select group of six nations in 1994, when the Polar Satellite Launch Vehicle (PSLV) successfully accomplished its mission of placing the remote sensing satellite, IRS-P2, in the intended orbit. The Indian Space Research Organization (ISRO) is developing an indigenous cryogenic engine GSLV.

The INSAT series of satellite launched earlier are performing well and provide vital services for telecommunications, television, meteorology, disaster warning and mobile satellite services transponders. Starting with IRS-1A in 1988, ISRO has launched many operational remote sensing satellites. Today, India has one of the largest constellations of remote sensing satellites in operation..

OCEANOGRAPHY

India has a coastline of more than 7,600km and 1,250 islands, with its Exclusive Economic Zone covering over 2 million sq. km and continental shelf extending up to 350 nautical miles. The Department of Ocean Development was established in 1981 to ensure optimum utilization of living resources, exploitation of non-living resources such as hydrocarbons and minerals, and to harness ocean energy. A National Institute of Ocean Technology was set up for the development of ocean -related technologies. It is also responsible for harnessing resources of the coastal belts and islands.

BIOTECHNOLOGY

India has been the forerunner among the developing countries in promoting multi-disciplinary activities in this area, recognizing the practically unlimited possibility of their applications in increasing agricultural and industrial production, and in improving human and animal life. The nucleus of research in this area is the National Biotechnology Board, constituted in 1982. A Department of Biotechnology was created in 1986.

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR)

CSIR was established in 1942, and is today the premier institution for scientific and industrial research. It has a network of 40 laboratories, two cooperative industrial research institutions and more than 100 extension and field centres. The Council's research programs are directed towards effective utilization of the country's natural resources and development of new processes and products for economic progress.

ACHEIVEMENTS OF INDIANS IN SCIENCE AND TECHNOLOGY

Science and technology have been an integral part of Indian civilization and culture over the past several millennia. Few are aware that India was the fountainhead of important foundational scientific developments and approaches. These cover many great scientific discoveries and technological achievements in mathematics, astronomy, architecture, chemistry, metallurgy, medicine, natural philosophy and other areas. A great deal of this travelled outwards from India. Equally, India also assimilated scientific ideas and techniques from elsewhere, with open-mindedness and a rational attitude characteristic of a scientific ethos. Some Indian scientists have left indelible imprints on the world S&T arena.

SIR CHANDRASEKHARA VENKATA RAMAN

Sir Chandrasekhara Venkata Raman was an Indian physicist whose work was influential in the growth of science in India. He was the recipient of the Nobel Prize for Physics in 1930 for the discovery that when light traverses a transparent material, some of the light that is deflected changes in wavelength. This phenomenon is called Raman scattering and is the result of the Raman effect. He was the first Asian and first non-White to receive any Nobel Prize in the sciences. In 1954 he was awarded the Bharat Ratna. India celebrates National Science Day on 28 February of every year to commemorate the discovery of the Raman effect in 1928.

JAGADISH CHANDRA BOSE

Acharya Sir Jagadish Chandra Bose was a Bengali polymath, physicist, biologist, botanist, archaeologist, as well as an early writer of science fiction. He pioneered the investigation of radio and microwave optics. IEEE named him one of the fathers of radio science. He also invented the crescograph. He also made a number of pioneering discoveries in plant physiology. He used his own invention, the crescograph, to measure plant response to various stimuli, and thereby scientifically proved parallelism between animal and plant tissues. He demonstrated the plants ability to feel, exemplified by the quivering of injured plants.

SATYENDRA NATH BOSE

Satyendra Nath Bose was an Indian physicist specializing in mathematical physics. He is best known for his work on quantum mechanics in the early 1920s, providing the foundation for Bose–Einstein statistics and the theory of the Bose–Einstein condensate. The class of particles that obey Bose–Einstein statistics, bosons, was named after him by Paul Dirac. Bose became an adviser to the then newly-formed Council of Scientific and Industrial Research (CSIR).

MEGHNAD SAHA

Meghnad Saha was an Indian astrophysicist best known for his development of the Saha equation, used to describe chemical and physical conditions in stars. Saha also helped to build several scientific institutions, such as the Physics Department in Allahabad University and the ***Institute of Nuclear Physics*** in Calcutta. He was also the chief architect of river planning in India. He prepared the original plan for the Damodar Valley Project.

MOKSHAGUNDAM VISHVESHWARIAH

M. Vishveshwariah was a notable Indian engineer, scholar, statesman and the Diwan of Mysore during 1912 to 1918. He was a recipient of the Indian Republic's highest honour, the Bharat Ratna, in 1955. Every year, 15 September is celebrated as Engineer's Day in India in his memory. He is held in high regard as a pre-eminent engineer of India. He was the chief designer of the flood protection system for the city of Hyderabad, as well as the chief engineer responsible for the construction of the Krishna Raja Sagara dam in Mysore.

PRASANTA CHANDRA MAHALANOBIS

P. C. Mahalanobis was an Indian scientist and applied statistician. He is best remembered for the Mahalanobis distance, a statistical measure. He made pioneering studies in anthropometry in India. He founded the Indian Statistical Institute, and contributed to the design of large-scale sample surveys.

HOMI JEHANGIR BHABHA

Homi Jehangir Bhabha was an Indian nuclear physicist and known as "father of Indian nuclear programme". Bhabha was the founding director of two well-known research institutions, namely the Tata Institute of Fundamental Research (TIFR) and the Trombay Atomic Energy Establishment (now named Bhabha Atomic Research Centre); both sites were the cornerstone of Indian development of nuclear weapons. Bhabha played a key role in convincing the Congress Party's senior leaders, most notable Jawaharlal Nehru who later served as India's first Premier, to start the ambitious nuclear programme. In 1948, Nehru led the appointment of Bhabha as the director of the nuclear programme and tasked Bhabha to develop the nuclear weapons soon after. Bhabha is generally acknowledged as the father of Indian nuclear power. He is credited with formulating the country's strategy in the field of nuclear power to focus on extracting power from the country's vast thorium reserves rather than its meagre uranium reserves. This thorium focused strategy was in marked contrast to all other countries in the world. The approach proposed by Bhabha to achieve this strategic objective became India's **three stage nuclear** power **programme.**

SUBRAHMANYAN CHANDRASEKHAR

Subrahmanyan Chandrasekhar was an Indian-American astrophysicist who, with William A. Fowler, won the 1983 Nobel Prize for Physics for key discoveries that led to the theory on the later evolutionary stages of massive stars. The Chandrasekhar limit is named after him. Chandrasekhar's most notable work was the astrophysical Chandrasekhar limit - the maximum mass of a stable white dwarf star. In 1999, NASA named the third of its four "Great Observatories" after Chandrasekhar. The Chandra X-ray Observatory was launched and deployed by Space Shuttle *Columbia* on July 23, 1999. The Chandrasekhar number, an important dimensionless number of magnetohydrodynamics, is named after him. The asteroid 1958 Chandra is also named after Chandrasekhar.

HAR GOBIND KHORANA

Har Gobind Khorana was a biochemist who shared the 1968 Nobel Prize for Physiology or Medicine with Marshall W. Nirenberg and Robert W. Holley for research that helped to show how the nucleotides in nucleic acids, which carry the genetic code of the cell, control the cell's synthesis of proteins.

SHANTI SWAROOP BHATNAGAR

Dr. Shanti Swaroop Bhatnagar was a great scientist of India. He was known as **"The Father of Research Laboratories"**. He is remembered for having established various chemical laboratories like Central Food Processing Technological Institute at Mysore, National Chemical Laboratory at Pune (Maharashtra), the National Metallurgical Laboratory at Jamshedpur and many others. Nehru established the Council of Scientific and Industrial Research (CSIR) under the leadership of Dr. Bhatnagar, who was appointed its first director-general.

CHAPTER – 2

SPACE RESEARCH

QUESTIONS ASKED IN THE PREVIOUS YEARS

1. Discuss the significance of GSLV in space research. (2001/30M)
2. What is cryogenic engine? Discuss its significance in India's space programme.(1997& 2001/20M)
3. What is remote sensing? What are its uses especially in the Indian context? (1998/20M)
4. What is PSLV? Describe its significance for India's space programme. (1995/20M)
5. Trace the progress of India's space research programme. What are its significant achievements? (1991/40M)
6. Describe how India's space programme has helped in its socio-economic development. (1996/40M)
7. What is the significance of geostationary orbit? What would happen if it becomes too crowded? (2000/30M)
8. What do you know about Indian National Satellite Systems? Describe its important features. (2008/30M)

Space Research involves dual use technology which means technology that has its application in both civilian and defence sectors. Space research in civilian sector is used for fabricating the satellites, weather forecasting etc. and in defence sector involves development of missiles for launching satellites.

INDIA'S SPACE RESEARCH PROGRAMME – ORIGIN & DEVELOPMENT

India's space programme had an early but modest beginning in 1961 when the Government of India entrusted the responsibility for space research and for the peaceful use of outer space to the Department of Atomic Energy (DAE), then under the leadership of Dr. Homi J. Bhabha. In 1962, DAE formed Indian National Committee for Space Research (INCOSPAR). In the same year, the work on establishing Thumba equatorial Rocket Launching Station (TERLS) started under the guidance of Dr. Vikram Sarabhai to organize a national space programme.

In 1969, INCOSPAR was replaced by the Indian Space Research Organization (ISRO). The ISRO and the launch vehicle program were shifted from Thumba to Sriharikota launching centre. In 1972, the Government of India constituted the Space Commission and established the Department of Space (DOS) and brought ISRO under DOS. DOS Secretariat and ISRO Headquarters are located at Antariksh Bhavan in Bengaluru.

OBJECTIVES

The Indian Space programme under the DoS aims to promote the development and application of space science and technology for the socio-economic benefit of the country. In order to be really able to do that, India needs to first develop and possess this technology before it can be profitably utilized in socio-economic development of the country.

Therefore, an even more important objective of our space programme has been to make India self reliant in space science and technology. India's space programme, primarily, involves the designing and fabrication of satellites and development of launch vehicles to launch these satellites.

ORGANISATIONAL SET-UP

SPACE COMMISSION AND DEPARTMENT OF SPACE

Space Commission formulates the policies and oversees the implementation of the Indian space programme to promote the development and application of space science and technology for the socio-economic benefit of the country.

DOS implements these programmes through, mainly, ISRO, Physical Research Laboratory (PRL), National Atmospheric Research Laboratory (NARL), North Eastern-Space Applications Centre (NE-SAC) and Semi-Conductor Laboratory (SCL).

Antrix Corporation, established in 1992 as a Government owned company, markets the space products and services.

RESEARCH CENTERS OF DOS

1. PHYSICAL RESEARCH LABORATORY (PRL)

The Physical Research Laboratory (PRL) is a national Research Institute for space and allied sciences, supported mainly by Department of Space, Government of India. This research laboratory has ongoing research programmes in Astronomy and Astrophysics, Atmospheric Sciences and Aeronomy, Earth Sciences, Solar System studies and Theoretical Physics. It manages the Udaipur Solar Observatory and is located in Ahmedabad.

Today PRL is actively involved in research, related to five major fields of science. PRL is also instrumental in the PLANEX planetary science and exploration programme.

2. SEMI-CONDUCTOR LABORATORY (SCL)

It is based in Chandigarh. It carries out Research & Development in the field of semiconductor technology, micro-electromechanical systems and process technologies relating to semiconductor processing.

3. NATIONAL ATMOSPHERIC RESEARCH LABORATORY (NARL)

It is located at Chittoor. NARL carries out fundamental and applied research in Atmospheric and Space Sciences.

4. NORTH EASTERN-SPACE APPLICATIONS CENTER (NE-SAC)

It is located at Shillong. It provides developmental support to North East by undertaking specific application projects using remote sensing, GIS, satellite communication and conducting space science research.

INDIAN SPACE RESEARCH ORGANIZATION (ISRO)

ISRO is the primary body for space research under the control of Government of India and one of the big six advanced space research organization that dominate space, others being NASA (U.S), RKA (Russia), CNSA (China), ESA (Europe) and JAXA (Japan). It was established in its modern form in 1969. It is located in Bangalore. ISRO's chief executive is a chairman, who is also chairman of the Indian government's Space Commission and the secretary of the Department of Space.

ISRO's first satellite, Aryabhata, was launched by the Soviet Union in 1975. Rohini, the first satellite to be placed in orbit by an Indian-made launch vehicle (Satellite Launch Vehicle 3) was launched in 1980.

The prime objective of ISRO is to develop space technology and its application to various national tasks. India's economic progress has made its space program more visible and active as the country aims for greater self-reliance in space technology. ISRO has successfully operationalised two major satellite systems namely Indian National Satellites (INSAT) for communication services and Indian Remote Sensing (IRS) satellites for management of natural resources; also, Polar Satellite Launch Vehicle (PSLV) for launching IRS type of satellites and Geostationary Satellite Launch Vehicle (GSLV) for launching INSAT type of satellites. The major establishments of DOS under ISRO and their area of activities are given in the following paragraphs:

a. SPACE APPLICATION CENTRE (SAC)

SAC is ISRO's R&D centre located at Ahmedabad. The core competence of the Centre lies in development of space borne and air borne instruments / payloads and their applications for national development and societal benefits. Among the fields of research at the SAC are geodesy, satellite based telecommunications, surveying, remote sensing, meteorology, environment monitoring etc.

b. ISRO SATELLITE CENTRE (ISAC)

It is located at Bangalore and responsible for the design, fabrication, testing and management of application satellites. The venue of eight successful spacecraft projects is also one of the main satellite technology bases of ISRO. The facility serves as a venue for implementing indigenous spacecraft in India. This centre has successfully designed and fabricated satellites like Aryabhata, Bhaskara, APPLE, and the IRS and INSAT series of satellites.

c. SATISH DHAWAN SPACE CENTRE (SDSC)

It is located at Sriharikota, A.P. It was earlier known as Sriharikota High Altitude Range (SHAR) Centre. With multiple sub-sites the Sriharikota island facility acts as a launching site for India's satellites. The Sriharikota facility is also the main launch base for India's sounding rockets. The centre is also home to India's largest Solid Propellant Space Booster Plant (SPROB) and houses the Static Test and Evaluation Complex (STEX).

d. VIKRAM SARABHAI SPACE CENTRE (VSSC)

It is located at Thumba, Thiruvananthapuram, Kerala. The largest base of ISRO is also the main technical centre and the venue for design and development of satellite launch vehicles like SLV-3, ASLV, PSLV and GSLV series.

The centre had its beginnings as the Thumba Equatorial Rocket Launching Station (TERLS) in 1962. It was renamed in honour of Dr. Vikram Sarabhai, the father of the Indian space program. In January 2007, the Space Capsule Recovery Experiment Module (SRE-1) was safely brought back to earth after 10 days in orbit. It made significant contribution to India's maiden mission to the Moon, Chandrayaan-1.

The major programmes at VSSC include Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV) and Rohini Sounding Rockets as well as the development of Geosynchronous Satellite Launch Vehicle (GSLV) Mk III, reusable Launch Vehicles, advanced technology vehicles, air-breathing propulsion and critical technologies towards human spaceflight.

e. NATIONAL NATURAL RESOURCES MANAGEMENT SYSTEM (NNRMS)

NNRMS is located at Bangalore and works under the administrative control of the department of space. It integrates the data from various remote sensing satellites with conventional data for effective management of country's natural resources. For example regular monitoring and estimation of crop acreage, yield etc. of various crops, monitoring of forest resources etc.

f. NATIONAL REMOTE SENSING CENTRE (NRSC)

It is located at Hyderabad. It is an autonomous body under the administration of DOS. It is the nodal agency for reception, archival, processing and dissemination of remote sensing data in the country. It also has training facilities at Dehradun in form of the Indian Institute of Remote Sensing.

g. INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY (IIST)

It is located at Thiruvananthapuram. The institute offers undergraduate and graduate courses in Aerospace engineering, Avionics and Physical Sciences. The students of first batch of IIST were inducted into different ISRO centres by end of July 2011.

h. LIQUID PROPULSION SYSTEMS CENTRE (LPSC)

It is engaged in development of liquid and cryogenic propulsion stages for launch vehicles and auxiliary propulsion systems for both launch vehicles and satellites. The LPSC has developed indigenous cryogenic upper stage for GSLV which was successfully test fired by ISRO on August 4, 2007.

i. INDIAN DEEP SPACE NETWORK (IDSN)

IDSN is located at Bangalore. This network receives, processes, archives and distributes the spacecraft health data and payload data in real time. It can track and monitor satellites up to very large distances, even beyond the Moon.

j. ISRO TELEMETRY, TRACKING AND COMMAND NETWORK (ISTRAC)

It is located at Bangalore and has a number of ground stations throughout India at Sriharikota, Thiruvananthpuram, Lucknow, Car Nicobar etc and all over the world in Port Louis (Mauritius), Bearslake (Russia), Biak (Indonesia) and Brunei. This centre provides Software development, ground operations, Tracking, Telemetry and Command (TTC) support for the launch vehicles and satellite missions.

k. ISRO INERTIAL SYSTEMS UNIT (IISU)

It is located at Thiruvananthpuram. It is responsible for carrying out R&D towards inertial sensors and systems and allied satellite elements for various missions. It developed the navigation system for PSLV.

l. MASTER CONTROL FACILITY (MCF)

It is located at Hassan, Karnataka. It is a multi-mission control centre charged with the responsibility of control and operation of INSAT and GSAT group satellites in orbit. Besides that, Geostationary satellite orbit raising, payload testing and in-orbit operations are performed at this facility. The MCF has earth stations and Satellite Control Centre (SCC) for controlling satellites and continuous monitoring of search rescue signals, VHRR and DCP downlinks. A second MCF-like facility named 'MCF-B' is being constructed at Bhopal.

m. ANTRIX CORPORATION LIMITED

The Antrix Corporation Limited, located at Antariksh Complex in Bangalore, is the apex marketing agency in the Department of Space, having access to the resources of Space industry. Antrix markets sub-systems and components for satellites, fabricates satellites to user specifications, provides launch services and tracking facilities, and also undertakes training of manpower and software development

OPERATIONAL CATEGORIES

The Indian Space Programme can be mainly divided in two categories:

- Satellite Programme
- Launch vehicle Programme

(Details are given after Future challenges to the Indian Space Programme)

FEW CONCEPTS

VERY HIGH RESOLUTION RADIOMETER (VHRR)

It is basically a telescope with a scan mirror which can receive images in the visible and infrared wavelengths. The VHRR provides round-the-clock, half-hourly, synoptic images of the weather conditions including cyclones, sea-surface and cloud temperatures. The data from the VHRR are individually processed and transmitted to the Indian Meteorological Department, New Delhi, where the cloud-cover images are produced. Usually a cloud-cover picture is taken every three hours, but at times of an approaching cyclone; more frequent images are generated, which helps in tracking the cyclone and predicting storm surges.

TRANSPONDERS

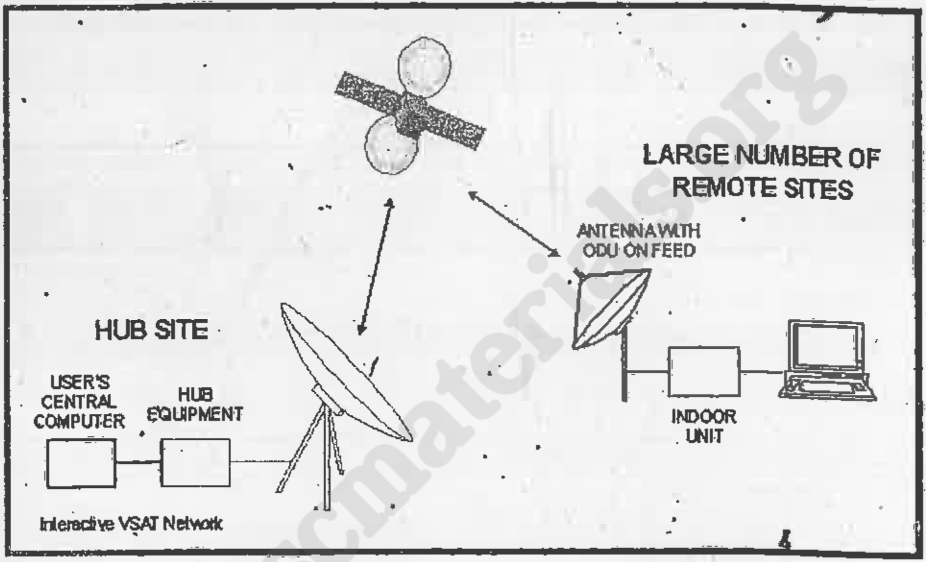
These are used in communication satellites. Transponders are electronic devices, which receive the signals beamed from the ground (uplink), amplify them a billion times, and beam them back to the ground (down link) at a different, lower frequency. Mainly three types of transponders are there,

- S-Band for Television broadcasting (2.5 to 2.7 GHz)

- .C-Band for Telecom (3.9 to 6.2 GHz)
- Ku Band for The internet (11 to 14 GHz)

VERY SHORT APERTURE TERMINAL (VSAT)

VSAT is an earthbound software-driven station used in satellite communications of data, voice and video signals, excluding broadcast television. It consists of two parts, a transceiver/outdoor unit (ODU) that is placed outdoors in direct line of sight to the satellite and a device that is placed indoors to interface the transceiver with the end user's communications device, such as a PC. The transceiver receives or sends a signal to a satellite transponder in the sky. The satellite sends and receives signals from a ground station computer that acts as a hub for the system. Each end user is interconnected with the hub station via the satellite, forming a star topology. The hub controls the entire operation of the network. For one end user to communicate with another, each transmission has to first go to the hub station that then retransmits it via the satellite to the other end user's VSAT.



ADVANTAGES / BENEFITS OF VSAT SATELLITE NETWORKS:

1. **Access in Remote Locations:** A Satellite in the Geo Synchronous orbit can cover around 33% of the earth's surface and can provide connectivity to any region covered by it. This is very useful for remote locations (rural areas, ships and coastal regions, hills, etc) where there is limited or no terrestrial connectivity. Remote locations can be provided health services (telemedicine), educational facilities (distance education), etc. using VSAT.
2. **Internet Access:** A VSAT Network can provide Internet access in addition to the point to point WAN links. It's all set to create a next major wave in the consumer broadband industry with the launch of satellites operating in the Ka band offering very high throughput, especially in the non metro regions. 'Always ON' broadband Internet services are possible with VSAT networks.
3. **VPN:** Satellites support encryption of all data transmitted between two sites or multiple sites, which make the creation of Virtual Private Networks (VPN) possible. Thus VSAT networks could find more acceptance in the corporate and Government/ Defence connectivity requirements.

4. **Mobile Access:** This makes TV broadcasters make broadcasts from anywhere – even when they are on the move. Another possible application could be mobile Internet access, while on the move.

5. **Reliable:** Satellite Networks are very reliable (having up-times in the magnitude of 99.5% and above) and have been field tested for many years now. Mission critical applications like Bank ATM's, Navy and Point of Sale appliances use VSAT.

6. **Back-up to Terrestrial Networks:** VSAT networks have always found applications in this area – they make a good back up network to the terrestrial networks (Leased Lines, MPLS circuits, Broadband DSL Connectivity, Internet Leased Lines, etc. **VSAT networks are not affected by natural calamities like earthquakes, storms etc.**

7. **Bandwidth on Demand:** VSAT networks support and are better suited for Bandwidth on Demand services than their terrestrial counterparts.

8. **Cost per connection is independent of the location/ distance:** With a VSAT network, the cost per node is independent on the number of nodes, and also distance between the various nodes. Compare that with Leased Lines, where the cost increases with more nodes and distance between the two locations.

LIMITATIONS

- **Extremely high initial cost** needed for building and launching satellites in the Geo-Synchronous orbit.
- **Bit Error Rate** is common for satellite based technologies
- Latencies (>200 ms) are still higher than their terrestrial equivalent technologies (<100 ms)
- **Trained man power** is required for installation and maintenance
- Other **competitive technologies** (Internet Leased Lines, 3G/HSDPA/4G Cellular technologies etc) offer much higher bandwidth at a lower cost than what is possible by VSAT based networks

TYPES OF ORBIT

Near Earth Orbit – It lies at a height of about 400 km above the surface of earth. It is the orbit closest to the earth, therefore the satellite orbiting in Neo has to overcome greater gravitational force of the earth. The satellites in Neo have shorter life span of 2or3 years. Usually experimental satellites are launched in to Neo. E.g Aryabhata, Bhaskara, Rohini and SROSS.

Low Earth Orbit – It lies at a height of about 900 km above the surface of earth. RSS are launched in to Leo, thus both experimental and operational satellites are launched in to Leo. E.g IRS series, Oceansat and TES

Geostationary Orbit (GSO) – It lies at a height of 36,000 km above the equator of the earth. An orbit around the Earth with a period equal to one sidereal day, which is Earth's average rotational period of 23 hours, 56 minutes, 4.091 seconds. For a nearly circular orbit, this implies an altitude of approximately 35,786 km (22,240 miles). If both the inclination and eccentricity are zero, then the satellite will appear stationary from the ground. Most commercial communications satellites and broadcast satellites operate in geostationary orbits. E.g INSAT series, MetSat.

Circular Orbit – The circular path traced by a satellite around a celestial body is called as circular orbit. For example, a geostationary satellite traces a circular path.

Elliptical Orbit – The oval shaped path traced by a satellite around a celestial body is known as elliptical orbit.

Geostationary Transfer Orbit (GTO) – An elliptical orbit which is located at a height of 200 km below the GSO. Geostationary satellites are first launched in GTO which then lift themself to GSO using their propulsion system.

CRYOGENIC ENGINES

The word 'cryo' means very low temperature. So cryogenic engines means engines running at a very low temperature. Here, the fuel used is liquid hydrogen and the oxidizer is liquid oxygen. To make liquid hydrogen, the minimum temperature required is -253C and for liquid oxygen is -186 C.

The higher propulsion efficiency of the cryogenic stage in terms of its specific impulse makes it suitable for the upper stage of GSLV. The development of a cryogenic stage using liquid oxygen stage using liquid hydrogen is important for large launch vehicles.

The crucial challenge is that at very low temperatures, the metals become brittle and their properties are not well known. Therefore, new welding techniques, new alloys are to be used. Various cryogenic fuel-oxidizer combinations have been tried, but the combination of liquid hydrogen (LH2) fuel and the liquid oxygen (LOX) oxidizer is one of the most widely used. Also storing liquid hydrogen and liquid oxygen require great expertise.

ISRO took up the challenge of building a cryogenic engine from the scratch after the US administration arm-twisted Russia in April, 1992 and July, 1993 into not selling cryogenic technology to India. The US claimed that the sale of the cryogenic technology to ISRO would violate the Missile Technology Control Regime (MTCR) guidelines since cryogenic engines could be used to propel missiles.

CE-7.5

The CE-7.5 is a cryogenic rocket engine developed by ISRO to power the upper stage of its GSLV Mk-2 launch vehicle. The engine was developed as a part of the Cryogenic Upper Stage Project (CUSP). It replaced the Russian cryogenic engine that powered the upper stage of GSLV Mk-1.

In 2014 the cryogenic engine performed successfully and launched the GSAT-14 satellite on GSLV Mk-2 rocket.

CE-20

The CE-20 is a cryogenic rocket engine being developed by the Liquid Propulsion Systems Centre, a subsidiary of ISRO. It is being developed to power the upper stage of the Geosynchronous Satellite Launch Vehicle III.

FUTURE CHALLENGES TO THE ISP

In the past three and half decades, India has come a long way in making the space programme self-reliant and useful for the social and economic development of the country. Now, India is able not only to design and build satellites like the INSAT (Indian National Satellites) and the IRS (Indian Remote Sensing Satellites) but also has capabilities to launch them in the desired orbits using indigenously designed and built rockets. After the PSLV operationalisation and GSLV testing, ISP is set to meet the growing needs of the country in the field of space technology. However, in order to achieve the complete self-reliance in space technology and its applications and to take this expertise to commercial level, a lot still needs to be done by ISRO.

- ISRO needs to take Indian technological capabilities from the Research and Development level to a commercial level, not just in relation to the country but the world market in a big way.
- It needs to sharply boost the frequency of its launches in order to reduce costs, thus making them cost competitive and commercially viable.
- It needs to develop the capabilities for build a much larger number of satellites than the current three to four satellites in a year.
- It has to perfect its GSLV rocket technology, which is currently based on Russian cryogenic engines, the supply of which is very limited and undependable and uncertain.
- Finally, it has to work towards supporting the country's national security efforts by providing space based sensors and communication systems based on state of the art technology keeping vigil on the global developments in this area.

ACHIEVEMENTS OF ISP

- All the credit goes to the contribution of the ISRO scientists that India has emerged as one of the 6 most important countries in the field of space research.
- We are now self-reliant in launching the Remote Sensing as well as Communication platforms.
- We can launch satellites for others too.
- The RSS imageries of our systems are the best in terms of quality and cost competitiveness.
- We have developed a market to sell satellite sub-systems& soundly rockets.
- ISRO has developed TERLS at Thumba in Tamilnadu for launching sounding rockets
- The ISP has contributed to our national security in the form of improving its surveillance capability.

SATELLITE PROGRAMME

India's satellite programme can be studied under the following categories:

- **Communication Satellites:** The Indian National Satellite (INSAT) system is one of the largest domestic communication satellite systems in Asia-Pacific region. Established in 1983 with commissioning of INSAT-1B, it initiated a major revolution in India's communications sector and sustained the same later. GSAT-18 joins the constellation of INSAT System consisting 14 operational satellites, namely - **INSAT**-3A, 3C, 4A, 4B, 4CR, 3DR and **GSAT**-6, 7, 8, 10, 12, 14, 15 and 16. The INSAT system provides services to telecommunications, television broadcasting, satellite newsgathering, societal applications, weather forecasting, disaster warning and Search and Rescue operations.

- **Earth Observation/Remote Sensing Satellites (RSS):** Starting with IRS-1A in 1988, ISRO has launched many operational remote sensing satellites. Today, India has one of the largest constellations of remote sensing satellites in operation. Currently, thirteen operational satellites are in Sun-synchronous orbit – **RESOURCESAT**-1, 2, 2A **CARTOSAT**-1, 2, 2A, 2B, **RISAT**-1 and 2, **OCEANSAT**-2, **Megha-Tropiques**, SARAL and **SCATSAT**-1, and *four* in Geostationary orbit- **INSAT**-3D, **Kalpana** & INSAT 3A, INSAT -3DR. The data from these satellites are used for several applications covering agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management.

- **Satellite Navigation:** Satellite Navigation service is an emerging satellite based system with commercial and strategic applications. ISRO is working to provide the satellite based Navigation services to meet the emerging demands of the Civil Aviation and to meet the user requirements of the positioning, navigation and timing based on the independent satellite navigation system. To meet the Civil Aviation requirements, ISRO is working jointly with Airport Authority of India (AAI) in establishing the GPS Aided Geo Augmented Navigation (**GAGAN**) system. To meet the user requirements of the positioning, navigation and timing services based on the indigenous system, ISRO is establishing a regional satellite navigation system called Indian Regional Navigation Satellite System (IRNSS).

- **Space Science and Exploration:** Indian space programme encompasses research in areas like astronomy, astrophysics, planetary and earth sciences, atmospheric sciences and theoretical physics. Achievements here include **AstroSat** (India's first dedicated Indian astronomy mission), **Mars Orbiter Mission** (India's first interplanetary mission), **Chandrayaan-1** (India's first mission to Moon). Chandrayaan-2 is in the works.

- **Experimental Satellites:** ISRO has launched many small satellites mainly for the experimental purposes. This experiment include Remote Sensing, Atmospheric Studies, Payload Development, Orbit Controls, recovery technology etc. The latest being two Nanosatellites (less than 10 Kg in weight) **INS-1A** and **INS-1B** in February, 2017.

- **Small Satellites:** The small satellite project is envisaged to provide platform for stand-alone payloads for earth imaging and science missions within a quick turnaround time.

- **University / Academic Institute Satellites:** ISRO has influenced educational institutions by its activities like making satellites for communication, remote sensing and astronomy. Capable Universities and institution can venture into space technology on-orbit with guidance and support from ISRO. For example, IIT Kanpur's Jugnu satellite was launched in 2011.

EARTH OBSERVATION SYSTEM / REMOTE SENSING SATELLITES (RSS)

The observation of the Earth from space is usually termed as remote sensing and satellites used for the purpose are known as Remote Sensing Satellites. The RS is a 'Space-based' earth observation system. It is a technique used for collecting information of any object on earth from about 900 km above the surface of earth, through the measurement of Electro Magnetic Spectrum of the sun that is reflected, scattered & remitted by objects on earth's surface. Indian Earth Observation System operates in Low Earth Orbit (LEO), Medium Earth Orbit (MEO) and Geostationary Earth Orbit (GEO).

Most of the RSS are polar, sun-synchronous satellites in low earth orbits (LEO) that is their latitudinal position above the earth is 1000, their movement is in pole to pole direction & their angular appearance in relation to sun is fixed. Such an orbit is chosen because it enables the satellite to take earth's pictures always at a fixed angle of illumination by the sun.

The RSS has the ability to provide a synoptic view of large areas for systematic and speedy collection & distribution of metrology, geology, geography, agriculture date within a short time period. Thus, the RSS provides key tips to planning & forms an integral part of resource management for the exploitation of renewable & natural resources of the earth. ISRO's remote sensing satellites include CARTOSATs, OCEANSATs, RESOURCESATs etc. which serve variety of purposes.

- **CARTOSATs** are useful for cartographic applications like mapping, urban and rural infrastructure development and management as well as application in Land Information System (LIS) and Geographical Information System (GIS), and DEM generation.
- OCEANSATs are used in Ocean and atmospheric studies (like atmospheric humidity and temperature vertical profiles from ROSA).
- RESOURSESAT is used in Resource Monitoring applications.
- **Megha-Tropiques** is used in Meteorological and Oceanographic applications. **RISAT** is used for Agriculture mapping, disaster management support activities.
- **SARAL** is used for Ocean applications.
- **The INSAT** series of satellites provide data for generating various parameters like cloud motion vectors, cloud top temperature, water vapour content, vertical profiles of temperature, humidity and facilitate weather forecasting, genesis of cyclones and their track prediction, etc.
- Currently, INSAT-3A, KALPANA-1, INSAT-3D and INSAT-3DR are providing meteorological data to the user community.

APPLICATIONS OF REMOTE SENSING SATELLITES

The Space borne remote sensing via satellites constitute a far greater improvement over ground based or even air-borne surveys because,

- It is cheaper& much speedier.
- It is more accurate &reliable.
- It is a multi dimensional survey tool whereby more than one type of surveys can be simultaneously carried out for a wide variety of application.

The remote sensing in India is an umbrella of National Natural Resources Management System (NNRMS). Remote Sensing has been applied in many diverse fields in India which are:

1. **Agriculture:** In the field of agriculture the RSS has helped in assessing the net crop area, Crop production forecasting, Movement of locust, Flood warning, damage assessments. On the bases of data provided by "IRS-1A & 1B", Planning Commission has divided the country into 15 Agro-climatic regions for better agriculture production.
2. **Natural Resource Management:** In the field of natural resource management, it has helped in accurately assessing the Land use and land cover mapping, mineral prospecting, forest resource surveys, Survey of forest cover distribution, monitoring of forest-fires etc. National Wasteland Maps have been prepared, identifying the types and extent of wastelands at village level, for 237 selected districts spread all over the country. These maps have been provided to the Department of Wasteland Development and district authorities for taking up Wasteland reclamation measures.
3. **Disaster Management & Meteorology:** The RSS finds its applications in the early warning mechanism for cyclones, the short term weather forecasting, and the warning, Monitoring as well as the Impact assessment for droughts and floods.
4. Sustainable **Development:** A major application of IRS data is the Integrated Mission for Sustainable Development (IMSD) which was initiated in 1992 to generate locale-specific action plans for sustainable development of natural resources, in terms of productivity, quality of environment and ecological set-up. The locale-specific prescriptions are generated under IMSD using data from IRS satellites and collateral socio-economic data in collaboration with the State Remote Sensing, Application Centre, Universities, private entrepreneurs and non-governmental organizations.
5. **Urban studies:** With the availability of high resolution panchromatic data from IRS-IC and IRS-ID, many new applications in urban studies have been carried out, such as urban sprawl, structural plans for cities, guide maps for Delhi, Bangalore etc.
6. **Defence:** The equipment on board IRS systems of satellites can act as a spy in the sky. They can pick up images of troop movements as well as deployments by the enemy. Remote Sensing has also helped to track a lost River bed in the Thar Desert of country which could be used for extending drinking H_2O facility to population.

SOME REMOTE SENSING SATELLITES

SARAL

SARAL or Satellite with **ARgos** and **ALtiKa** is a cooperative altimetry technology mission of ISRO and CNES (Space Agency of France). SARAL will aid work in many fields like Climate monitoring; Ocean, earth system and climate research; Continental ice studies; Protection of biodiversity; Improvement of maritime security etc.

RADAR IMAGING SATELLITES (RISAT)

It has an all weather-imaging sensor capable of taking images in cloudy and snow covered regions and also both during day and night. ISRO currently operates two Radar Imaging Satellites - **RISAT-1** and **RISAT-2**.

CARTOSAT-2

It is an Earth observation satellite that carries a state-of-the-art panchromatic (PAN) camera that provide scene-specific spot imagery. The data from the satellite will be used for detailed mapping and other cartographic applications..

RESOURCESAT-2

It is a follow on mission to Resourcesat-1 and will help in resource monitoring.

SCATSAT-1

SCATSAT-1 is a continuity mission for Oceansat-2 Scatterometer to provide wind vector data products for weather forecasting, cyclone detection and tracking services.

COMMUNICATION SATELLITE PROGRAMME (INSAT SYSTEM)

Indian National Satellite (INSAT) system is a multi-agency, multipurpose application satellite system for domestic communication, meteorology observation & data relay, nationwide direct satellite TV broadcasting & radio-programme distribution. Also provides services in the areas of disaster warning a distress alert i.e. search & rescue missions. INSAT satellites are a joint venture of the Department of Space, Department of Telecommunications, India Meteorological Department, All India Radio (AIR) and Doordarshan. The overall coordination and management of INSAT system rests with the Secretary-level INSAT Coordination Committee.

The INSAT satellites are monitored and controlled by Master Control Facilities that exist in Hassan and Bhopal. The INSAT system is Geo-synchronous (GS) in nature as opposed to that of the RSS, which are Sun-synchronous. A GS Satellite is a common satellite rotating in circular equatorial orbit at a fixed altitude of about 36,000 km, goes around the earth once in about 24 hours. As the earth takes the same time to rotate on its axis, the satellite appears stationery and hence the name Geo-Synchronous Satellite (GSS). The Communication satellites are normally GSS. The high equatorial altitude gives them coverage of maximum surface area of the earth and GS movement allows the sat to have a continuous view of the same part of the earth, thereby giving continuous application benefits.

SOME COMMUNICATION SATELLITES:

INSAT-3D

INSAT-3D is a meteorological, data relay and satellite aided search and rescue satellite launched in 2013.

KALPANA-1

KALPANA-1, is an exclusive meteorological satellite launched by PSLV in September 2002. It carries very high resolution radiometer (VHRR) and a data relay transponder (DRT) payloads to provide meteorological services. Its original name was METSAT.

EDUSAT

Configured for audio-visual medium employing digital interactive classroom lessons and multimedia content, EDUSAT was launched by GSLV in September 2004. Its transponders and their ground coverage are specially configured to cater to the educational requirements. The satellite carries a Ku-band transponder, five Ku-band spot beam transponders for South, West, Central, North and North East regional coverage and six Extended C-band transponders.

INSAT-4A 4B AND 4CR

They are mainly used for to Direct-to-Home television services.

GSAT 12

It provides services like tele-medicine, point of sale transactions and satellite internet access.

GSAT-14

In 2014, GSAT-14 was launched by a GSLV Mk II, which incorporated an Indian-built cryogenic engine on the third stage. GSAT-14 is part of the GSAT series of satellites. The satellite is expected to provide enhanced broadcasting services.

APPLICATIONS OF INSAT

The INSAT system is a multipurpose satellite. It has revolutionized telecom, broadcasting & meteorological services. The various services provided by GSS are as under:

1. **Telecommunication**: INSAT satellites have contributed to the communication revolution in India. Remote and far flung areas have been effectively connected to the rest of the world through these satellites.
2. **Television**: INSAT has been a major catalyst in the rapid expansion of television coverage in India. Satellite television now covers over 65 percent of the Indian landmass and over 80 percent of the Indian population.
3. **Educational TV (ETV)**: It broadcasts general enrichment programme for University students, mainly to provide quality education within the reach of students in small towns and Education Media Research Centres and Audio Visual Research Centres at different places and UGC, Delhi produce villages, under the country-wide classroom programme of the UGC, launched in 1984.
4. **Satellite News Gathering**: Satellite news gathering has been used several times, via the INSAT transponders to enable real-time news coverage from the field. Prasar

Bharati is processing 5 Outdoor-Broadcast terminals to cover important events in the field.

5. **Radio Networking:** Radio Networking (RN) through INSAT has been designed to provide reliable high fidelity 10/15 kHz programme channels for national as well as regional networking of radio programme. Nearly 200 All India Radio stations have been equipped with S-band receiver terminals and 17 C-band terminals. The Interactive exchange of programme also takes place between any two or more uplink stations.

6. **Meteorology:** The meteorological payload of INSAT is designed to collect and transmit meteorological, hydrological and oceanographic data from unattended remote data collection platforms to aid in weather forecasting. One hundred meteorological data collection platforms have been installed all over the country and at the Indian base station.

A unique feature of the INSAT meteorological payload is its capability to provide advance warning through a novel Cyclone Warning Dissemination System.(CWDS). The system operates through a network of small dish antennas and special CWDS receivers. Finally, the Satellite Aided Search and Rescue (SAS&R), Distress Alert Service provides distress alert and position location service through lower-earth orbiting search and rescue satellite system. It provides coverage to a large part of the Indian Ocean region, rendering distress alert services to Bangalore, Bhutan, Kenya, Maldives, Nepal, Seychelles, Somalia, Sri Lanka, Tanzania and Zanzibar.

VILLAGE RESOURCE CENTRE (VRC)

Combining the services offered by INSAT and IRS satellites, a new concept namely Village Resource Centre (VRC) is envisaged to provide information on natural resources, land and water resources management, tele-medicine, tele-education, adult education, vocational training, health and family welfare programmes has been established. Nearly 500 such VRCs have been established in the country.

LAUNCH VEHICLE PROGRAMME (LV)

The launch vehicle is basically a rocket that carries the satellite into the orbit. A competent and robust LV forms the core of any successful space programme. Geopolitical and economic considerations during the 1960s and 1970s compelled India to initiate its own launch vehicle program. By the 1980s, research had yielded the Satellite Launch Vehicle-3 and the more advanced Augmented Satellite Launch Vehicle (ASLV. ISRO further applied its energies to the advancement of launch vehicle technology resulting in the creation of Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV) technologies.

The Indian Space Programme has made a successful transition in terms of technology acquisition and launch vehicle development. PSLV has become a favoured carrier for satellites of various countries due to its reliability and cost efficiency, promoting unprecedented international collaboration. The Geosynchronous Satellite Launch Vehicle (GSLV) with indigenous Cryogenic stage, graduated to become an operational vehicle for communication satellites. ISRO is moving forward with the development of heavy lift launchers, human spaceflight, reusable launch vehicles, semi-cryogenic engines, etc., to cater to different payloads and an array of missions.

1. SATELLITE LAUNCH VEHICLE (SLV)

The Satellite Launch Vehicle (SLV or SLV-3) was intended to reach a height of 500 km and carry a payload of 40-50 kg. SLV-3 has launched Rohini-class satellites to near earth orbits. Its first launch took place in 1979 and the final launch in 1983, before it was decommissioned. Incidentally, SLV-3 is the first stage of Agni missiles.

2. AUGMENTED SATELLITE LAUNCH VEHICLE (ASLV)

The Augmented Satellite Launch Vehicle was a 5-stage solid propellant rocket with the capability of placing a 150 kg satellite into LEO, around 900 kilometres above the earth's surface. This project was started by the ISRO during the early 1980s to develop technologies needed for a payload to be placed into a geostationary orbit. Its design was based on LV. Two of its launches were successful, before it was decommissioned.

3. POLAR SATELLITE LAUNCH VEHICLE (PSLV)

The Polar Satellite Launch Vehicle is an expendable launch system developed to allow India to launch its Indian Remote Sensing (IRS) satellites into sun synchronous orbits, a service that was, until the advent of the PSLV, commercially viable only from Russia. PSLV has demonstrated a variety of missions such as Sun Synchronous Polar Orbit (SSPO), Geosynchronous Transfer Orbit (GTO) and Low Earth orbits (LEO) thereby emerging as the workhorse launch vehicle of India.

PSLV has been designed and developed at Vikram Sarabhai Space Centre. The PSLV had its first launch in 1993.

PSLV AND ITS SIGNIFICANCE FOR INDIAN SPACE PROGRAMME

PSLV, country's first operational launch vehicle is a 4-stage rocket. It was designed to carry much heavier satellites (120 kg) of the IRS class to polar sun-synchronous orbits. It was the first Indian launch vehicle to use liquid fuel & the liquid fuel engine 'VIKAS' was indigenously developed. The 2nd& 4th stage use liquid propellant, where as 1st& 3rd stage use solid propellant – HTPB (Hydroxyl Terminal poly butadiene). India so far has launched PSLVs (C_1 – C26) & (D_1 – D_3). Only PSLV – D_1 is an unsuccessful launch. The first successful PSLV flight i.e. PSLV-D_2 marked India's elite place in the Space club, as India became only the 6th nation in the world to attain the capability of launching 1000 – 1200 kg satellite in to PSO.

The success of the 1st stage HTPB booster has confirmed the Inter Continental Ballistic Missile (ICBM) capabilities with India. The success of PSLV has confirmed all the technologies to make missiles that can hit targets, perhaps, tens of thousands of kilometres away. Although India's space programme is totally oriented towards peaceful application of space technology, there are countries, which want India to give up its space launch vehicle programme as it confirm ICBM status because there was enormous on India to confirm to Missile Technology control Regime (MTCR) & Nuclear Non Proliferation Treaty (NPT).

The success of PSLV made India a potential competitor to the West for the multi-billion dollar global launch services market. India can benefit through its lower launch price as Indian launch facilities could became attractive specially for launching satellite of other developing countries. PSLV has helped in launching spy satellites in the Remote sensing orbit, thus strengthen our national security. The latest significance of PSLV series is that it has launched India's exclusive Meteorology satellite, which will help the country in constantly tracking the movement of cyclones & thus precious life in property can be saved. Thus, PSLV strengthens India's capabilities & status in space technology & its possible military, commercial & civilian applications.

4. GEOSTATIONARY SATELLITE LAUNCH VEHICLE (GSLV).

The GSLV is an expendable launch system operated by the ISRO. It was developed to enable India to launch its INSAT-type satellites into geostationary orbit and to make India less dependent on foreign rockets. Geosynchronous Satellite Launch Vehicle (GSLV) is a three-stage vehicle with solid, liquid and cryogenic upper stage, designed to place 2-ton class of communication satellites in Geosynchronous Transfer Orbit (GTO). Early GSLV launches used cryogenic upper stages supplied by Russia. India originally tried to buy the technology to build a cryogenic upper stage from Russia, but under pressure from the United States, that technology was not provided. Therefore, ISRO developed the cryogenic engine used in the GSLV indigenously.

GSLV VARIANTS

GSLV Mk.I - This variant was capable of launching 1500 kg into geostationary transfer orbit and later improved to carry 1900 kg. This has been retired.

GSLV Mk.II -This variant uses an Indian cryogenic engine, the CE-7.5, and is capable of launching 2500 kg into geostationary transfer orbit. Previous GSLV vehicles (GSLV Mk.I) have used Russian cryogenic engines.

GSLV Mk.III -The GSLV-Mk III is the next generation launch vehicle of ISRO capable of launching 4 ton class of satellites to Geosynchronous Transfer orbit (GTO).

GSLV AND ITS SIGNIFICANCE FOR INDIAN SPACE PROGRAMME

GSLV is the most advanced generation of India's launch vehicles after ASLV & PSLV. It is a three-stage launch vehicle. GSLV is capable of lifting a 2500 kg INSAT class satellites in to GTO from where it can be manoeuvred& moved into the final geostationary orbit 36,000 km above the equator. The First launch of GSLV was GSLV-D_1 which placed experimental communication satellite GSAT-1 in the GTO. The second was GSLV-D_2 which placed the GSAT-2 in GTO.

The launch of GSLV has put India in the select League of Nations with the capability to place multipurpose satellites in orbit & send space missions. GSLV has given India the ICBM status which can direct an explosive to a distance of 5000 km. Besides, the immaculate guidance system of GSLV is an added advantage. The success of GSLV gives India the capability of launching communication satellites into the GTO. It makes India a pot player in the commercial launch services for communication satellites. The armed forces need a dedicated satellite which can provide them imagery of a particular region on demand. They also need ability to launch low earth sat for detailed surveillance. With the launch of GSLV such a scenario has became a reality.

SATELLITE NAVIGATION

GAGAN (GPS Aided GEO Augmented Navigation)

GAGAN is a joint project of Indian Space Research Organisation and Airports Authority of India. It is an indigenous Satellite-Based Regional GPS Augmentation System also known as Space-Based Augmentation System (SBAS). GAGAN offers enhanced satellite navigation signals over India which is ten times more precise than GPS. The GAGAN system was dedicated to nation in July, 2015. GAGAN is capable of providing Navigation Services to Departure, en-route and landing operations to suitably equipped aircrafts. The system is providing Satellite-based Navigation services with accuracy and integrity required for civil aviation applications and is also providing efficient air traffic management services over the Indian Airspace.

NAVIC / Indian Regional Navigation Satellite system (IRNSS)

The Indian Regional Navigation Satellite System (IRNSS) is an autonomous regional satellite navigation developed by the ISRO which would be under complete control of the Indian government. Navigation Indian Constellation (NavIC) or IRNSS is an independent system designed to provide accurate position information service to users in India as well as the region extending up to 1,500 km from its boundary, which is its primary service area. The requirement of such a navigation system is driven by the fact that access to foreign government-controlled global navigation satellite systems is not guaranteed in hostile situations, as happened to Indian military depending on American GPS during Kargil War. The IRNSS would provide two services viz,

- the Standard Positioning Service (SPS) open for civilian use and
- the Restricted Service (RS), encrypted one, for authorised users (military)

Seven satellites with the prefix "IRNSS-" will constitute the space segment of the IRNSS, with three in geostationary orbit and four in inclined geosynchronous orbit. Starting with IRNSS-1A in 2013, all 7 satellites were launched by 2016 with IRNSS-1G being the last. On the occasion of the launch of IRNSS-1G, Hon'ble Prime Minister of India dedicated IRNSS to the nation and named it as 'NavIC' - Navigation with Indian Constellation.

The system is intended to provide an absolute position accuracy of better than 10 meters throughout Indian landmass and better than 20 meters in the Indian Ocean as well as a region extending approximately 1,500 km around India.

SPACE SCIENCE AND EXPLORATION

ASTROSAT

ASTROSAT is a first dedicated Indian Astronomy satellite mission, which will enable multi-wavelength observations of the celestial bodies and cosmic sources in X-ray and UV spectral bands simultaneously. The scientific payloads cover the Visible, UV, soft and hard X-ray regimes. The uniqueness of ASTROSAT lies in its wide spectral coverage extending over visible, UV, soft and hard X-ray regions.

MANGALYAAN - MARS ORBITER MISSION

The Mars Orbiter Mission (MOM), also called *Mangalyaan* is a spacecraft orbiting Mars since 24 September 2014. It was launched on 5 November 2013 using PSLV-C25 by the ISRO. It is India's first interplanetary mission and ISRO has become the fourth space agency to reach Mars, after the Soviet space program, NASA, and the European Space Agency. It is also the first nation to reach Mars orbit on its first attempt, and the first Asian nation to do so. The mission is a "technology demonstrator" project to develop the technologies for design, planning, management, and operations of an interplanetary mission. It carries five instruments that will help advance knowledge about Mars to achieve its secondary, scientific objective.

The spacecraft is currently being monitored from the Spacecraft Control Centre at ISRO Telemetry, Tracking and Command Network (ISTRAC) in Bangalore with support from Indian Deep Space Network (IDSN) antennae at Byalalu.

OBJECTIVES

The **primary objective** is to showcase India's rocket launch systems, spacecraft-building and operations capabilities. Specifically, the primary objective is to develop the technologies required for design, planning, management and operations of an interplanetary mission. The **secondary objective** is to explore Mars' surface features, morphology, mineralogy and Martian atmosphere using indigenous scientific instruments.

PAYLOAD

The scientific payload consists of five instruments:

Atmospheric studies:

1. **Lyman-Alpha Photometer (LAP)** – a photometer that measures the relative abundance of deuterium and hydrogen from Lyman-alpha emissions in the upper atmosphere. Measuring the deuterium/hydrogen ratio will allow an estimation of the amount of water loss to outer space.
2. **Methane Sensor for Mars (MSM)** – will measure methane in the atmosphere of Mars, if any, and map its sources.

Particle environment studies:

3. **Mars Exospheric Neutral Composition Analyser (MENCA)** – is a quadrupole mass analyser capable of analysing the neutral composition of particles in the exosphere.

Surface imaging studies:

4. **Thermal Infrared Imaging Spectrometer (TIS)** – will measure the temperature and emissivity of the Martian surface, allowing for the mapping of surface composition and mineralogy of Mars.
5. **Mars Colour Camera (MCC)** – will provide images in the visual spectrum, providing context for the other instruments.

ISRO plans to send a follow-up mission with a greater scientific payload to Mars between 2018 and 2020. This mission will likely consist of a lander and rover, rather than being orbiter-only.

CHANDRAYAAN-I (MISSION TO MOON)

Chandrayaan-1 was India's first unmanned lunar probe. It was launched by the ISRO in October 2008, and operated until August 2009. The mission included a lunar orbiter and an impactor. The vehicle was successfully inserted into lunar orbit on 8 November 2008.

On 14 November 2008, the Moon Impact Probe separated from the Chandrayaan orbiter and struck the South Pole in a controlled manner, making India the fourth country to place its flag on the Moon after Soviet Union, United States and Japan. The probe impacted near Shackleton Crater ejecting underground soil that could be analysed for the presence of lunar water ice.

It carried high resolution remote sensing equipment for visible, near infrared, and soft and hard X-ray frequencies. Over a two-year period, it surveyed the lunar surface to produce a complete map of its chemical characteristics and three-dimensional topography. The Polar Regions are of special interest as they might contain ice. Among its many achievements was the discovery of the widespread presence of water molecules in lunar soil.

COMPLETION OF PRIMARY OBJECTIVES

Although the mission was less than 10 months in duration, and less than half the intended 2 years in length, a review by scientists termed the mission successful, as it had completed 95% of its primary objectives, consisting of:

- To construct the complex spacecraft with 11 scientific instruments.
- To place the spacecraft in a circular orbit around the Moon by orbit rising manoeuvres from a near Earth orbit.
- To place the Flag of India on the Moon.
- To carry out imaging operations and to collect data on the mineral content of the lunar soil.
- To set up a deep space tracking network and implement the operational procedures for travel into deep space.

PAYLOADS

The scientific payload had a total mass of 90 kg and contained five Indian instruments and six foreign instruments.

INDIAN PAYLOADS

- **Terrain Mapping Camera (TMC)** is a CCD camera which was used to produce a high-resolution map of the Moon. The aim of this instrument was to completely map the topography of the Moon. When used in conjunction with data from Lunar Laser Ranging Instrument (LLRI), it can help in better understanding of the lunar gravitational field as well.
- **Hyper Spectral Imager (HySI)** performed mineralogical mapping in the 400-900 nm band.

- **Lunar Laser Ranging Instrument (LLRI)** determines the height of the surface topography by sending pulses of infrared laser light towards the lunar surface and detecting the reflected portion of that light.
- **Moon Impact Probe (MIP)** developed by the ISRO, is an impact probe which consisted of a C-band Radar altimeter for measurement of altitude of the probe, a video imaging system for acquiring images of the lunar surface and a mass spectrometer for measuring the constituents of the lunar atmosphere.

The American Institute of Aeronautics and Astronautics (AIAA) has selected ISRO's Chandrayaan-1 mission as one of the recipients of its annual AIAA SPACE 2009 awards, which recognizes key contributions to space science and technology. The International Lunar Exploration Working Group (ILEWG) chose the Chandrayaan-1 team for giving the International Cooperation award.

CHANDRAYAAN-2

Chandrayaan-2, is India's second lunar exploration mission. It includes a lunar orbiter, a lander and a lunar rover. The Chandrayaan-2 is planned to be launched by GSLV MkII launch vehicle during first quarter of 2018. Many new technologies are being developed indigenously to achieve the mission requirements. ISRO will have the prime responsibility for the orbiter and rover, while Roskosmos (of Russia) will be responsible for the lander.

DESIGN

ORBITER

The orbiter will orbit the Moon at an altitude of 200km. The mission would carry five payloads on the orbiter. The approximate launch mass will be 1,400 kg.

LANDER

Unlike Chandrayaan-1, where Moon Impact Probe (MIP) crash landed on the surface of the Moon, Chandrayaan-2 will soft land its Lander with Rover on the Lunar surface.

ROVER

The wheeled rover will move on the lunar surface and will pick up soil or rock samples for on-site chemical analysis. The data will be sent to Earth through the Chandrayaan-2 orbiter. The rover will operate on solar power. IIT Kanpur is developing three subsystems to provide mobility:

1. Stereoscopic camera based 3D vision - will provide the ground team controlling the rovers a 3D view of the surrounding terrain.
2. Kinematic traction control - will enable the rover to negotiate the rough lunar terrain using independent steering provided on four of its wheels.
3. Control and motor dynamics - The rover will have six wheels, each driven by an independent electric motor. Four of the wheels will also be capable of independent steering. A total of 10 electric motors will be used for traction and steering.

PAYLOADS

ORBITER PAYLOAD

- **Large Area Soft X-ray Spectrometer** (CLASS) and **Solar X-ray monitor** (XSM) for mapping major elements present on the lunar surface.
- **L and S band Synthetic Aperture Radar (SAR)** for probing the first few tens of metres of the lunar surface for the presence of different constituents, including water ice. SAR is expected to provide further evidence confirming the presence of water ice below the shadowed regions of the Moon.
- **Imaging IR Spectrometer (IIRS)** for mapping of lunar surface over a wide wavelength range for the study of minerals, water molecules and hydroxyl present.
- **Neutral Mass Spectrometer (ChACE-2)** to carry out a detailed study of the lunar exosphere.
- **Terrain Mapping Camera-2 (TMC-2)** for preparing a three-dimensional map essential for studying the lunar mineralogy and geology.

ROVER PAYLOAD

- Laser induced Breakdown Spectroscope (LIBS)
- Alpha Particle Induced X-ray Spectroscope (APIXS)

There are plans to include a seismometer to study Moon-quakes.

ADITYA-L1 (SPACECRAFT)

The original Aditya - L1 mission was conceived as a small satellite in a ~800km orbit carrying one payload to study solar corona. The mission has been enhanced and termed as Aditya-L1 mission carrying seven payloads, which was approved in 2015. It is scheduled for launch during 2020 timeframe by PSLV-XL. Aditya-L1 can provide observations on the corona and in addition can provide observations on the solar chromosphere using an UV payload and on the photosphere and flares using X-ray payloads. These payloads taken together are expected to provide a comprehensive understanding of how solar flares originate and propagate. In addition, the charged particle detectors and the magnetometer payloads can provide information on charged particles and the magnetic field which emanate from the eruptive events. To enable this, the Aditya-L1 spacecraft is to be placed in a halo orbit around the Sun-Earth Lagrangian point 1 (L1) which is about 1.5 million km from the Earth..

SMALL SATELLITES

SRMSAT

SRMSAT is a Nano Satellite built by students at Sri Ramaswamy Memorial University, Chennai. It was in 2011 atop to monitor Greenhouse gases in atmosphere. It has a design life of one year. SRMSAT's primary mission is the development of a nanosatellite platform for future missions. Its secondary mission is the monitoring of greenhouse gasses using an Argus spectrometer.

JUGNU

Jugnu is an Indian technology demonstration and remote sensing satellite which is operated by the IIT, Kanpur. In 2011, Jugnu was launched into LEO. It is a nanosatellite which will be used to provide data for agriculture and disaster monitoring. It has a design life of one year. Jugnu's primary instrument is the Micro Imaging System, a near infrared camera which will be used to observe vegetation. It also carries a GPS receiver to aid tracking, and is intended to demonstrate a microelectromechanical (MEMS) based inertial measurement unit (IMU).

ANTRIX: COMMERCIAL ARM OF ISRO

Antrix Corporation Limited (ACL), a wholly owned Government of India Company under Department of Space, was set up in 1992, at Bangalore as the commercial arm of ISRO. It has undertaken a number of initiatives for global marketing of space products and services emanating from the Indian space program. There has been a steady increase in the revenues and customer base of the company. This government owned company's mandate is to provide commercial edge to the Indian space capabilities by marketing hardware and components and providing know-how and consultancy services.

The transponder provisioning services have registered a significant growth in business operations with increased capacity being provided during the year for diverse applications. Currently, a large number of transponders from INSAT / GSAT fleet are provisioned to Indian users for Television Broadcasting (TV), Direct-to-Home (DTH), Digital Satellite News Gathering (DSNG), Very Small Aperture Terminal (VSAT) and Telephony services. The services realised in the process address a wide range of social and business needs. Additional transponders were provisioned for meeting the ever-increasing requirement of customers. The rapidly growing demand from VSAT services from Government and public sector enterprises, along with pan India digitisation efforts in the context of DTH, is expected to fuel the demand for satellite communication capacity in the country. Antrix is geared to meet these requirements in a timely manner.

Antrix was able to establish PSLV as a reliable satellite launcher and could consolidate the launcher as a major player in the small satellite launch business. Till date, PSLV has launched 79 international customer satellites from 21 countries. During this year, ANTRIX was able to enter into contract with major small satellite companies like Planet Labs, Terra Bella, etc., and launched 12 nano satellites and 3 mini satellites, as co-passengers in PSLV-C34.Antrix Corporation Ltd.

It has now emerged as a major supplier of high quality satellite resource data, currently accounting for nearly one fourth of the world market for satellite resource data.

SPACE CAPSULE RECOVERY EXPERIMENT I (SRE I)

SRE-I was launched by PSLV C7 in multi satellite launch mission in 2007. It is a spherical cone made of mild steel jointly developed by VSSC and ISAC. It was successfully deorbited and brought back to earth and recovered from Bay of Bengal twelve days after its successful launch. Only US, Russia, China and EU possess the technology to bring an orbiting satellite back to earth.

SIGNIFICANCE

1. It is the forerunner to ISRO mastering the re-entry technology.
2. It is pre-cursor to recovery technology.
3. It is also the technology pre-runner to India building a reusable launch vehicle like US space shuttle so that India can send a manned mission into space.

SPACE CAPSULE RECOVERY EXPERIMENT II (SRE II)

The main objective of SRE II is to realize a fully recoverable capsule and provide a platform to conduct microgravity experiments on Micro-biology, Agriculture, Powder Metallurgy, etc. SRE-2 is proposed to be launched on board PSLV.

REUSABLE LAUNCH VEHICLE (RLV)

It is be a combination of a Rocket and an aircraft. It will carry a space capsule, which will act as the last stage of RLV. It is designed like an aircraft which after completing its function in the outer space by launching the satellite re-enters into earth's atmosphere, glides down and lands like a conventional aircraft. The various stages of the RLV that fall into the ocean are recovered and are reused many times. This helps in the cost of launching a satellite considerably, as generally 70% of the cost is spent in developing various stages of the LV, which are not used more than once

ISRO has been developing India's first-RLV. As a first step towards realizing a Two Stage To Orbit (TSTO) fully re-usable launch vehicle, a series of technology demonstration missions have been conceived. For this purpose a Winged Reusable Launch Vehicle technology Demonstrator (RLV-TD) has been configured. The RLV-TD will act as a flying test bed to evaluate various technologies viz., hypersonic flight, autonomous landing, powered cruise flight and hypersonic flight using air-breathing propulsion.

- The first experimental mission towards the realisation of fully reusable launch vehicle i.e., RLV-TD was successfully conducted on May 23, 2016 from the First Launch Pad of Satish Dhawan Space Centre. The RLV-TD was initially carried by a special solid rocket booster up to an altitude of 49 km, where it was separated. After separation from the booster rocket, the vehicle climbed further up to an altitude of 69 km, and then had a controlled descent through the dense atmosphere and finally glided into the sea after simulating the landing manoeuvres. With this flight, critical technologies such as autonomous navigation, guidance & control and reusable thermal protection system have been successfully demonstrated along with new technologies like carbon-carbon nose cap, hot structures and Lithium ion batteries. The success of this mission along with the demonstration of robustness of autonomous mission management now gives confidence to pursue further developmental activities in the area of winged re-entry vehicles.

SCRAMJET ENGINE

India in 2016 became only the fourth nation (after the US, Russia and European Space Agency) to flight-test a scramjet engine, a technology that scientists claim could change the way space travel is undertaken in the future. Though the full development of the engine, for an "air breathing" propulsion system that significantly reduces the amount of fuel needed to fire up engines on a rocket, is decades away, it is a significant milestone for the Indian Space Research Organisation (ISRO).

While rockets usually carry both fuel and oxidiser for easy combustion, scramjet engine uses the oxygen from atmosphere to compress fuel, thus reducing the weight of rocket and increasing the efficiency. In a scramjet engine, the combustion of fuel occurs in a stream of air compressed by the forward speed of the aircraft itself, as opposed to a normal jet engine, in which the fan blades compresses the air. The airflow in the engine remains supersonic i.e greater than the speed of sound. The engine can only be used in the atmospheric phase of a rocket's flight as there is little to no oxygen once the rocket exits the bounds of the earth's atmosphere.

The engine will reduce the weight of the vehicle during lift-off by more than half, enabling it to carry heavier payloads into orbit. It will help bring down launch costs by reducing the amount of oxidiser that needs to be carried along with fuel. The engine can be used both in ascent and descent phase of the vehicle.

ISRO's aims to place this new rocket alongside the Re-usable Launch Vehicle (RLV) which India had already successfully. Many countries like Japan, China, Russia and Europe are only in the initial or testing phase of Supersonic combustion technology.

INDIAN SPACE VISION 2025

The space vision 2025, a future roadmap for ISRO was unveiled at the Indian Science Congress Session in 2003, in Bangalore. The vision document spells out the steps to take our space programme to greater heights. As India has already achieved self-sufficiency in fabrication of satellites, thus now emphasis is on achieving self reliance in launching capabilities. It includes:

1. Satellite based communication and navigation systems for rural connectivity, security needs and mobile services;
2. Enhanced imaging capability for natural resource management, weather and climate change studies;
3. Space science missions for better understanding of solar system and universe;
4. Planetary exploration;
5. Development of Heavy lift launcher;
6. Reusable Launch Vehicles - Technology demonstrator missions leading to Two Stage To Orbit (TSTO); and
7. Human Space Flight

INDIAN HUMAN SPACEFLIGHT PROGRAM

The objective of Human Spaceflight Programme (HSP) is to undertake a human spaceflight mission to carry a crew of two on ISRO Orbital Vehicle to Low Earth Orbit (LEO) and return them safely to a predefined destination on earth. The programme is proposed to be implemented in phases. Critical technologies that are needed to undertake human spaceflight are Crew Module (CM) System, Crew Escape System (CES) and Environmental Control and Life Support System (ECLSS).

ISRO will set up a full-fledged training facility in Bangalore for training astronauts. ISRO is planning to build a third launch pad at Sriharikota for manned missions with extra facilities like entry into the crew capsule and an escape chute. The trials for the manned space missions began with the 600 kg Space Capsule Recovery Experiment (SRE), launched using the Polar Satellite Launch Vehicle (PSLV) rocket, and safely returned to earth 12 days later. This demonstrates India's capability to develop heat-resistant materials necessary for re-entry technology.

Space Diplomacy Of India

Space diplomacy is the way of using cooperation in space technology as an instrument to enhance diplomatic ties and to develop the geo strategic interests. It has the potential to enhance India's diplomatic relations with developed as well as developing countries.

Technological capabilities in outer space have long been used as an effective tool of foreign policy. For instance, US used its LandSat satellites to share the data or Russia included an Indian cosmonaut Rakesh Sharma in its manned space flight.

Broad Aims Of Cooperative Endeavours has been:

- Strengthening ties with the other nations.
- New scientific and technological development for domestic advancement and global collaboration.
- Role in development of International policy / law regarding the space technologies.
- Assistance to other developing countries in the field of space technology.

India's Cooperative Endeavour:

International Cooperation is an important aspect of India's space policy. India is a party to UN Treaties in the field of exploration and Peaceful Uses of Outer Space (Exception is the Moon Treaty, which was not ratified).

India is actively supporting regional cooperative initiatives such as UN affiliated Centre for Space Science and Technology Education for AP, APSRAF, space applications and capacity building programs of ASEAN, SAARC, UN ESCAP etc.

The development of SAARC (South Asia Association for Regional Cooperation) regional satellite system is being spearheaded by the Indian space agency; it is an excellent example of the Indian policy of strengthening relations with the immediate neighbour. The SAARC satellite will be helpful to the South Asian countries in India's neighbourhood for fighting poverty and illiteracy, scientific advancement and open up the opportunities for the youths of these countries.

ISRO is also exploring the possibility of expanding the footprints of India's home-grown seven satellite navigation system, IRNSS (Indian Regional Navigation Satellite System) the last and seventh satellite of which is due for launch soon ,to the neighbouring countries.

With a view to project its soft power through the sharing of its space expertise, India is looking at the possibility of setting up a ground station in Fiji that could ultimately serve as a hub for sharing space expertise with the Pacific island nations. ISRO already operates ground stations in Mauritius, Brunei and Indonesia to help track the Indian satellites launched from Satish Dhawan Space Centre(SDSC) in Sriharikota island on India's eastern coast. India is actively pursuing a proposal with ASEAN to establish a ground station in Vietnam to receive, process and use data from Indian satellites for a variety of applications including disaster management and support and also to provide training in space science ,technology and applications.

India has offered to share Indian space expertise with the countries in South East region where China, Japan, Australia and USA are jockeying to acquire a strategic edge. India has offered Bangladesh its expertise to build and launch its domestic satellites.

Various cooperative missions are Chandrayaan-1 mission with effective multi-lateral cooperation, Megha-Tropiques and SARAL are Indo-French joint satellite missions.

Cooperation among BRICS in the case of Brazil, cooperation potentials had been identified in relation to space sciences, exchange of earth observation data, and tracking assistance among others. Cooperative dialogues are in process namely China and South Africa. India's earth observation satellite data were received in China through commercial channels.

India also shares data with countries and is a part of international forums such as United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UNSPIDER).

India has launched satellites for countries that do not have space launch capabilities as well as for countries like France, Canada and even USA who find Indian services reliable as well as reasonable.

Thus India has taken excellent steps towards utilisation of space diplomacy and more can achieved considering India's capabilities for regional and global diplomacy. With China rapidly consolidating its position in many of the third world countries as a most sought after high tech partner for making available space services and satellite systems on highly affordable terms, India cannot afford to lag behind in taking its expertise in space technology for the benefit of the third world countries.

Indian Space Research Organisation (ISRO) has created a record by pulling off more than 100 space missions including probes to the Moon and Mars. With such an impressive credentials, India can reach out to the third world countries including its immediate neighbours with its space expertise custom made to tackle the problems of poverty and backwardness.

OTHERS:

NASA'S MARS ATMOSPHERE AND VOLATILE EVOLUTION MISSION (MAVEN)

MAVEN is a space probe designed to study the Martian atmosphere while orbiting Mars. Mission goals include determining how the Martian atmosphere and water, presumed to have once been substantial, were lost over time. MAVEN was successfully launched aboard an Atlas V launch vehicle at the beginning of the first launch window on November 18, 2013. Following the first engine burn of the Centaur second stage, the vehicle coasted in low Earth orbit for 27 minutes before a second Centaur burn of five minutes to insert it into a heliocentric Mars transit orbit. On September 22, 2014, MAVEN reached Mars and was inserted into an areocentric elliptic orbit 6,200 km

The MAVEN mission has four primary scientific objectives:

- Determine the role that loss of volatiles to space from the Martian atmosphere has played through time.
- Determine the current state of the upper atmosphere, ionosphere, and interactions with the solar wind.
- Determine the current rates of escape of neutral gases and ions to space and the processes controlling them.
- Determine the ratios of stable isotopes in the Martian atmosphere.

MARS 2020 ROVER MISSION

The Mars 2020 rover mission is a Mars planetary rover mission concept under study by NASA with a proposed launch in 2020. It was announced by NASA in December 2014. It is intended to investigate an astrobiologically relevant ancient environment on Mars, investigate its surface geological processes and history, including the assessment of its past habitability and potential for preservation of biosignatures within accessible geological materials.

As proposed, the rover would be based on the design of *Curiosity*. While there will be differences in scientific instruments and the engineering required to support them, the entire landing system (including the sky crane and heat shield) and rover chassis can essentially be recreated without any additional engineering or research. This reduces overall technical risk for the mission, while saving funds and time on development. A radioisotope thermoelectric generator—originally intended as a backup part for *Curiosity*—will power the rover.

PAYLOADS:

- **Planetary Instrument for X-Ray Lithochemistry** (PIXL), an x-ray fluorescence spectrometer to determine the fine scale elemental composition of Martian surface materials.
- **Radar Imager for Mars' subsurface experiment** (RIMFAX), a ground-penetrating radar to image dozens of meters beneath the rover.

- Mars **Environmental Dynamic Analyzer** (MEDA), a set of sensors that will provide measurements of temperature, wind speed and direction, pressure, relative humidity and dust size and shape.
- **The Mars Oxygen ISRU Experiment** (MOXIE), an exploration technology investigation that will produce oxygen (O_2) from Martian atmospheric carbon dioxide (CO_2). This technology could be used in the future to support human life or make rocket fuel for return missions.
- **SuperCam,** an instrument that can provide imaging, chemical composition analysis and mineralogy in rocks and regolith from a distance.
- **Mastcam-Z,** a stereoscopic imaging system with the ability to zoom.
- **Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals** (SHERLOC), an ultraviolet Raman spectrometer that uses fine-scale imaging and an ultraviolet (UV) laser to determine fine-scale mineralogy and detect organic compounds.

MICROSATELLITES

These are custom built satellites to be used for specific objectives such as TV broadcasting Telecom, weather forecasting etc.

- Flexibility is the hallmark of these satellites.
- These satellites weigh about 50 kg.
- The ease with which it can be launched makes it especially relevant for urgent missions like dealing with natural disasters. They can be launched in a couple of days.
- Operating in clusters they can be put to many innovative uses in space along with performing traditional functions.
- The Micro satellites can be launched into space by using high-flying fighter aircraft which cuts down its launching cost.

Israel is pioneer in development of the Micro satellites. The world's 1st Micro satellite called 'TECHSAT-2' was launched by Israel in 1998. Indian and Israel signed an agreement in 2002 for corporation in space research and development. Anna University at Chennai is developing India's 1st weighing around 60 kg. India has already launched Micro satellites of other countries like KITSAT-2 of South Korea, Bird and Tubsat of Germany and Proba of Belgium. With their power and flexibility they have capacity to revolutionize space industry as PC's have done in fields of IT, making it more accessible for longer and diverse number of uses.

DEVELOPMENTS OVER THE LAST YEAR (MAY'16-MAR'17)

ISRO launches 104 satellites in one go (Feb 2017)

ISRO created launch history by placing a record 104 spacecraft in their desired orbits. They were launched on the PSLV C-37. C-37 was largely a commercial flight as 101 satellites belonged to six other countries. Of the 101 foreign, 96 were from the US, cover a large part of the Indian Ocean and will also include Bangladesh, Bhutan, Maldives, Nepal, Seychelles, Sri Lanka and Tanzania for providing distress alert services.

Communication satellite GSAT-18 successfully launched (Oct 2016)

India's Communication satellite GSAT-18,built by ISRO, was launched from the European spacepad of Kourou in French Guiana. GSAT was launched into Geosynchronous Transfer Orbit. It will provide telecommunication services and will strengthen the space agency's current fleet of 14 operational telecom satellites. GSAT 18 will support television, telecommunication, VSAT and digital satellite news gathering. Currently, ISRO is dependent on Ariane-5 rocket for carrying its heavier satellites and is developing GSLV Mk III for this purpose:

ISRO places satellites in 2 orbits for the first time (Sep 2016)

ISRO's PSLV C-35 rocket has launched a total of eight satellites into two different orbits. This launch is the first mission of PSLV in which it had launched its payloads into two different orbits. The satellites included SCATSAT-1 for weather related studies and seven co-passenger satellites, including two satellites PRATHAM from IIT Bombay and PISAT from PES University, Bengaluru. SCATSAT-1 was placed into a 720 km Polar SSO whereas; the two Universities / Academic Institute Satellites were placed into a 670 km polar orbit.

Japan launches 'space junk' collector (Dec 2016)

More than 50 years of human space exploration since the Soviet-launched Sputnik satellite in 1957 has produced this hazardous belt of orbiting debris. There are estimated to be more than 100 million pieces in orbit that are posing a growing threat to future space exploration.

Japan launched a cargo ship bound for the International Space Station (ISS) carrying a 'space junk' collector. The capsule called Kounotori, or white stork is also carrying nearly 5 tons of food, water and other supplies for the astronauts. Scientists at the Japan Aerospace Exploration Agency (JAXA) are experimenting with a half-mile long tether to pull junk out of orbit around Earth, clearing up tonnes of space clutter, including cast-off equipment from old satellites and pieces of rocket. The tether, made of aluminium strands and steel wire, is designed to slow the debris, pulling it out of orbit. This experiment is part of an international initiative designed to make space safer for astronauts by getting rid of space junk.

while one satellite each is from the Netherlands, Switzerland, Israel, Kazakhstan and the UAE.

Among Indian satellites, a satellite of ISRO's Cartosat-2 series was also launched.The satellite will be used for mapping urban and rural regions, regulation of coastal land use, management of road networks, water distribution and other several other purposes. The two ISRO Nano satellites (INS-1A and INS-1B) are carrying instruments from its Space Applications Centre (SAC) and Laboratory for Electro Optics Systems (LEOS) for experiments.

Remote sensing satellite Resourcesat-2A launched (Dec 2016)

Remote sensing satellite Resourcesat-2A was launched from Sriharikota aboard the PSLV-C36 rocket. RESOURCESAT-2A is a Remote Sensing satellite intended for resource monitoring. The 1,235-kg spacecraft is orbiting pole-to-pole, at 824 km from Earth. There are three cameras of different resolution that will give regular micro and macro information on land and water bodies below, farm lands and crop extent, forests, mineral deposits, coastal information, rural and urban spreads besides helping in disaster management. The three cameras can cover the land below in a unique three-tier manner. RESOURCESAT-2A is a follow on mission to RESOURCESAT-1 and RESOURCESAT-2, launched in 2003 and 2011 respectively. RESOURCESAT-2A is intended to continue the remote sensing data services to global users provided by the two earlier satellites.

Application: Government unveils satellite surveillance to curb illegal mining (Oct 2016)

In a path-breaking move, the mines ministry came out with mining surveillance system (MSS), a pan-India surveillance network using remote-sensing satellite technology, to check illegal mining. Maps of mining leases have been geo-referenced in MSS, which are superimposed on the latest satellite remote sensing scenes obtained from CARTOSAT and USGS (US Geological Survey). The system checks 500 meters around the existing mining lease boundary to search for any unusual activity relating to illegal mining. Any discrepancy will be flagged off as a trigger. MSS will cover major minerals including coal, iron ore and bauxite at present and minerals like sand, lime stone and granite will be brought under its ambit later.

GSLV-F05 puts INSAT-3DR in orbit (Sep 2016)

INSAT-3DR is an advanced weather satellite put in the Geosynchronous Transfer Orbit (GTO) and then transferred into the Geosynchronous Transfer Orbit (GTO). GSLV-F05 has indigenously developed cryogenic upper stage as its fourth stage. Like its predecessor INSAT-3D, INSAT-3DR carries a Data Relay Transponder as well as a Search and Rescue Transponder. Thus, INSAT-3DR will provide service continuity to earlier meteorological missions of ISRO and further augment the capability to provide various meteorological as well as search and rescue services.

The INSAT-3DR will generate images of the Earth from a geostationary altitude of 36,000 km every 26 minutes and provide information on parameters such as sea surface temperature, snow cover, cloud motion winds, among others. The major users of the service will be the Indian Coast Guards, Airports Authority of India (AAI), Directorate General of Shipping, Defence Services and fishermen. The Indian service region will

CHAPTER – 3

NUCLEAR RESEARCH

QUESTIONS ASKED IN THE PREVIOUS YEARS:

1. How has India's nuclear programme contributed to the economic and defence requirements of the country? (1997/40M)
2. What is a fast breeder reactor? Comment on its suitability in the Indian context. (1999/40M)
3. Where is Indira Gandhi Centre for Atomic Research located? (1999/1M)

INDIA'S NUCLEAR RESEARCH PROGRAMME (NRP)

India's NRP aims to develop and utilize nuclear energy for **"peaceful purposes"** such as power generation, applications in agriculture, medical sciences, industry and other areas. India is today globally acknowledged as one of the advanced countries in nuclear technology. The country is self-reliant and excels in the expertise covering the complete nuclear cycle from exploration and mining to power generation and from applications of nuclear technology to waste management and other safety issues.

Although nuclear armament has not been the thrust area of India's nuclear programme, India did visualize a need to adopt a more comprehensive approach to security - encompassing economic strength, internal cohesion and technological up gradation. In the emerging global scenario, India remains a firm and consistent proponent of general and complete global nuclear disarmament, as against any discriminatory doctrine/treaty in this regard.

The nuclear tests of May 1998 do not dilute India's commitment to the long held objective of nuclear disarmament. This sets the country apart from other nuclear weapon states, which reject global nuclear disarmament proposals because they refuse to visualize their security without nuclear weapons. As a nuclear weapon state, India is even more conscious of its responsibility in this regard, and initiatives in the pursuit of global nuclear disarmament continue to be taken by India.

India's nuclear weapon capability is meant only for self-defence and seeks only to ensure that India's security, independence and integrity are not threatened in future. India's nuclear doctrine is based on maintaining a minimum credible deterrence and a no-first use policy as opposed to nuclear war fighting or warning doctrines. It is therefore, natural for India to take initiatives that aim to reduce the threat of break out of nuclear war and also to take initiatives that promote peaceful and more meaningful applications of nuclear technology.

India's nuclear doctrine is based on maximum restraints in the use of nuclear weapons, absolute political control over decision making and an effective interface between civilian and military leaders in the management of its atomic quiver.

ORGANIZATIONAL SET UP

THE AGENCIES

1. ATOMIC ENERGY COMMISSION (AEC)

The Indian Atomic Energy Commission was first set up in August 1948 in the then Department of Scientific Research, which was created a few months earlier in June 1948. The Department of Atomic Energy (DAE) was set up on August 3, 1954 under the direct charge of the Prime Minister through a Presidential Order. Subsequently, in accordance with a Government Resolution dated March 1, 1958, the Atomic Energy Commission (AEC) was established in the Department of Atomic Energy.

2. ATOMIC ENERGY REGULATORY BOARD (AERB)

The AERB is India's nuclear safety organization, created in 1983 to ensure that the use of ionising radiation and nuclear energy in India does not cause undue risk to health or environment. The AERB is responsible for monitoring all of the nuclear matters that fall under the DAE. It reports to the AEC. It is currently responsible for overseeing the design and construction of five reactors and the safe operations of twenty already-established reactors, as well as regulation at all other nuclear facilities in the country.

3. DEPARTMENT OF ATOMIC ENERGY (DAE)

The Department of Atomic Energy (DAE) was established in 1954, with the following mandate.

I. To generate safe, economic electrical power from nuclear energy.

II. To build research reactors and to utilize the radioisotopes produced in these reactors for application in the field of agriculture and medicine.

III. To develop advanced technology in areas such as accelerators, lasers, biochemistry, information technology and material including development of non-nuclear and strategic materials like titanium.

IV. To encourage technology transfers and interaction with industry for industrial and social development.

V. To provide necessary support to basic research in nuclear energy and related fields of science.

VI. To encourage international cooperation in advanced are of research and in mega-science projects to realize the benefits of state-of-the-art science and technologies.

The important institutions under the Department of Atomic Energy includes BARC, Indira Gandhi Centre for Atomic Research (IGCAR), Nu clear Power Corporation of India (NPCIL), Centre for Advanced Technology (CAT), Indian Rare Earth Limited (IREL), Atomic Minerals Division (AMD), Electronic Corporation of India Limited, Variable energy Cyclotron Centre (VECC), Uranium Corporation of India Limited, Heavy Water board, Nuclear Fuel Complex, and Bhartiya Nabhikiya Vidyut Nigam Ltd. (BHAVINI).

AGENCIES AT GLOBAL LEVEL

1. INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA)

It is a specialized agency of UN established in 1957. It came into being to implement US president Dwight Eisenhower's "Atoms for Peace" proposal. It seeks to promote the peaceful use of nuclear energy and to prevent its use for military purposes. IAEA teams regularly inspect nuclear facilities all over the world to ensure that civilian reactors are not being used for military purposes.

2. WORLD ASSOCIATION OF NUCLEAR OPERATORS (WANO)

It is a NGO established in 1989 at London after the Chernobyl nuclear accident. In this nuclear scientists from 33 countries are represented including that of India. The main function of WANO is in the domain of safety of reactor operations. It certifies the safety aspects of nuclear reactors that are open to its inspection.

NUCLEAR POWER PLANT

A nuclear power plant (NPP) is a thermal power station in which the heat source is one or more nuclear reactors. As in a conventional thermal power station the heat is used to generate steam which drives a steam turbine connected to a generator which produces electricity. Nuclear power plants are usually considered to be base load stations, which are best suited to constant power output.

HISTORY

Electricity was generated by a nuclear reactor for the first time ever on December 20, 1951 at the EBR-I experimental station near Arco, Idaho in the United States. On June 27, 1954, the world's first nuclear power plant to generate electricity for a power grid started operations at Obninsk, USSR. The world's first commercial scale power station, Calder Hall in England opened in October 17, 1956.

HOW IT WORKS

The conversion to electrical energy takes place indirectly, as in conventional thermal power plants. The heat is produced by fission in a nuclear reactor (a light water reactor). Directly or indirectly, water vapour (steam) is produced. The pressurized steam is then usually fed to a multi-stage steam turbine. Steam turbines in Western nuclear power plants are among the largest steam turbines ever. After the steam turbine has expanded and partially condensed the steam, the remaining vapour is condensed in a condenser. The condenser is a heat exchanger which is connected to secondary side such as a river or a cooling tower. The water is then pumped back into the nuclear reactor and the cycle begins again. The water-steam cycle corresponds to the Rankine cycle. In India, at present, twenty one nuclear power reactors produce 5,780.

TYPES OF REACTORS

LIGHT WATER REACTOR (LWR):

All LWRs use ordinary water as both coolant and neutron moderator. Following are sub-types of LWR:

1. Pressurized Water Reactor (PWR):

In a PWR, the primary coolant (water) is pumped under high pressure to the reactor core where it is heated by the energy generated by the fission of atoms. The heated water then flows to a steam generator where it transfers its thermal energy to a secondary system where steam is generated and flows to turbines which, in turn, spins an electric generator. It constitutes the large majority of the world's nuclear power plants (notable exceptions being the United Kingdom, Japan and Canada). Russia's VVER reactors are similar to U.S. PWRs.

2. Boiling Water Reactor (BWR):

It is the second most common type of electricity-generating nuclear reactor after the pressurized water reactor (PWR), also a type of light water nuclear reactor. The main difference between a BWR and PWR is that in a BWR, the reactor core heats water, which turns to steam and then drives a steam turbine. In a PWR, the reactor core heats water, which does not boil. This hot water then exchanges heat with a lower pressure water system, which turns to steam and drives the turbine. Many variant developed like, Advanced boiling water reactor (ABWR), Simplified boiling water reactor (SBWR), Economic Simplified Boiling Water Reactor (ESBWR).

3. Super Critical Water Reactor (SCWR):

The supercritical water reactor (SCWR) is a concept Generation IV reactor, mostly designed as light water reactor (LWR) that operates at supercritical pressure (i.e. greater than 22.1 MPa). The term critical in this context refers to the critical point of water, and must not be confused with the concept of criticality of the nuclear reactor. The water heated in the reactor core becomes a supercritical fluid above the critical temperature of 374 °C, transitioning from a fluid more resembling liquid water to a fluid more resembling saturated steam (which can be used in a steam turbine), without going through the distinct phase transition of boiling. As of 2012, the concept was being investigated by 32 organizations in 13 countries

4. Fast Breeder Reactor (FBR):

As opposed to current light water reactors which use uranium-235 (0.7% of all natural uranium), fast breeder reactors use Uranium-238 (99.3% of all natural uranium). It has been estimated that there is up to five billion years' worth of uranium-238 for use in these power plants. (see next section below for details)

HEAVY WATER REACTOR (HWR):

The use of heavy water as the moderator is the key to the **PHWR (pressurized heavy water reactor)** system, enabling the use of natural uranium as the fuel (in the form of ceramic UO2), which means that it can be operated without expensive uranium enrichment facilities.Heavy water is used as moderator and coolant. These features mean that a PHWR can use natural uranium and other fuels, and does so more efficiently than light water reactors (LWRs).

FAST BREEDER REACTOR (FBR)

A nuclear reactor that produces the same kind of fissile materials as it burns is called a breeder reactor (BR). Like U-235, Pu-239 can also sustain a chain reaction. BRs while using Pu as a fuel can produce more Pu-239 than it consumes by converting non-fissionable U-238 that predominates in natural Uranium ore. With fast neutrons, the chances of absorption by U-238 are more & hence these reactors *do not use moderator to slow down neutrons*, therefore, are called FBRs. For this reason ordinary liquid water, being a moderator as well as a neutron absorber is an undesirable primary coolant for fast reactors. Because large amounts of water in the core are required to cool the reactor, the yield of neutrons and therefore breeding of Pu-239 are strongly affected. Thus, FBR need specific heat removal system such as liquid sodium (Na) or steam coolants in view of their higher power density.

Advantages

a. In PHWRs nuclear chain is slowed down by moderators whereas in FBRs this reaction is sustained by fast neutrons.

b. The efficiency of conversion i.e. ratio of fresh fuel produced to fuel consumed is 1.2 to 1.3 in FBR & 0.6 in PHWRs.

c. Radioactivity released in to atmosphere is less.

India's first 40 MW Fast Breeder Test Reactor (FBTR) established by IGCAR attained criticality on 18 October 1985. Thus, India became the sixth nation to have the technology to build and operate an FBTR after/US, UK, France, Japan and the former USSR.

PROTOTYPE FAST BREEDER REACTOR (PTFBR)

In its golden jubilee year, Department of Atomic Energy (DAE) has succeeded in laying the foundation of its prototype 2nd generation nuclear reactor at Kalpakkam in August 2004. It has been developed by Indira Gandhi Centre for Atomic Research, Kalpakkam on the basis of successful operation of the FBTR since 1985.

It will be a 500 mw capacity facility and will cost around Rs. 3500 crore. It will be completed in 8 years. PFBR will use plutonium-uranium oxide as the fuel and liquid sodium as the coolant. India is only country in the world which is engaged in the research & development of FBR and conversion of Thorium into U-233.

Bhartiya **Nabhikiya Vidyut Nigam Limited (BHAVINI)** has been given the project management responsibility of PFBR. The PFBR will be a major technology development for the DAE which is comparable to the (Integrated guided missile development programme) IGMDP of DRDO. So it is a technological milestone.

The development of Breeder technology is significant to India. India has a unique resource imbalance as far as nuclear fuel is concerned. Our known uranium resources (60,000 tonnes) will last only for 30 years generally just 12000 MW power. So, any further nuclear power generation is possible only with imported uranium or imported reactors or development of FBR for converting vast thorium deposits of the country into U-233. Because of the international restrictions first two options are of limited use to India. Thus, FBR technique looks the viable option with its capability to amplify energy from natural uranium many fold by converting 70-80% of non-fissile U into Fissile Plutonium or converting thorium into U-233.

COMPACT HIGH TEMPERATURE REACTOR (CHTR)

It is an innovative reactor being developed by BARC which will break water (H_2O) into molecules of H_2& O_2 at a temperature of 1000°C by making use of thermo-chemical processes.

Advantages

a. Traditional Pressurised heavy water reactors (PHWR) generate electricity at 300°C; whereas new reactor will function at 1000°C.

b. The new reactor will explore whether nuclear energy can be used for other purposes than electricity generation.

c. The H_2 produced will be used as fuel in vehicles.

d. CHTR will use U-233 as the fuel

NUCLEAR POWER IN INDIA

Nuclear power is the fourth-largest source of electricity in India after thermal, hydroelectric and renewable sources of electricity. The total Installed capacity of power utilities in the country was 272 GW as of March 2015. Out of this, thermal power plants accounted for an overwhelming 71% of the total installed capacity in the country. Hydro power plants come next , accounting for 13% of the total installed Capacity. The share of Nuclear energy was only 1.82% (5.78 GW).

The Government in July 2014, had announced tripling of the then existing capacity of 4780 MW in the next ten years, that is by the year 2024. A capacity of 1000 MW has already been added with the start of commercial operation of Kudankulam Nuclear Power Project Unit-1 (KKNPP 1) in December, 2014. The nuclear power capacity is expected to reach 10080 MW on progressive completion of projects presently under commissioning/construction by the year 2018.

India has been making advances in the field of thorium-based fuels, working to design and develop a prototype for an atomic reactor using thorium and low-enriched uranium, a key part of India's three stage nuclear power programme.

Operational

Unit	Type	Capacity (MWe)	Since
TAPS-1 (Tarapur, Maharashtra)	BWR	160	October 28, 1969
TAPS-2 (Tarapur, Maharashtra)	BWR	160	October 28, 1969
TAPS-3 (Tarapur, Maharashtra)	PHWR	540	August 18, 2006
TAPS-4 (Tarapur, Maharashtra)	PHWR	540	September 15, 2005
RAPS-1 (Rawatbhata, Rajasthan)	PHWR	100	December 16, 1973
RAPS-2 (Rawatbhata, Rajasthan)	PHWR	200	April 1, 1981

Unit	Type	Capacity (MWe)	Since
RAPS-3 (Rawatbhata, Rajasthan)	PHWR	220	June 1, 2000
RAPS-4 (Rawatbhata, Rajasthan)	PHWR	220	December 23, 2000
RAPS-5 (Rawatbhata, Rajasthan)	PHWR	220	February 4, 2010
RAPS-6 (Rawatbhata, Rajasthan)	PHWR	220	March 31, 2010
MAPS-1 (Kalpakkam, Tamil Nadu)	PHWR	220	January 27, 1984
MAPS-2 (Kalpakkam, Tamil Nadu)	PHWR	220	March 21, 1986
NAPS-1 (Narora, Uttar Pradesh)	PHWR	220	January 1, 1991
NAPS-2 (Narora, Uttar Pradesh)	PHWR	220	July 1, 1992
KAPS-1 (Kakrapar, Gujarat)	PHWR	220	May 6, 1993
KAPS-2 (Kakrapar, Gujarat)	PHWR	220	September 1, 1995
KGS-1 (Kaiga, Karnataka)	PHWR	220	November 6, 2000
KGS-2 (Kaiga, Karnataka)	PHWR	220	May 6, 2000
KGS-3 (Kaiga, Karnataka)	PHWR	220	May 6, 2007
KGS-4 (Kaiga, Karnataka)	PHWR	220	November 27, 2010
KNPP-1 (Koodankulam, Tamil Nadu)	VVER	1000	July 13, 2013
Total Capacity		**5780**	

BWR – Boiling Water Reactor

PHWR – Pressurized Heavy Water Reactor

VVER – Water-water Energetic reactor

PFBR – Pressurized Fast Breeder Reactor

KAPS – Kakrapara atomic power station

NAPS – Narora atomic power station

MAPS – Madras atomic power station

RAPS – Rajasthan atomic power station

TAPS – Tarapur atomic power station

KGS – Kaiga atomic power station

KNPP – Koodankulam Nuclear Power Plant

Under construction

Unit Under Construction	Type	Capacity (MWe)

Unit Under Construction	Type	Capacity (MWe)
KNPP-2 (Koodankulam, Tamil Nadu)	LWR	1000
KAPS-3 (Kakrapara, Gujarat)	PHWR	700
KAPS-4 (Kakrapara, Gujarat)	PHWR	700
RAPS-7 (Rawatbhata, Rajasthan)	PHWR	700
RAPS-8 (Rawatbhata, Rajasthan)	PHWR	700
MAPS (Bhavini, Tamil Nadu)	PFBR	470
Total Capacity		**4270**

BARC'S ATOMIC REACTORS

i. **Apsara:** India's first atomic reactor was commissioned in 1957. One megawatt swimming pool type reactor produces radio isotopes. It is also the first atomic reactor in Asia.

ii. **Cirus (Canada-India-Reactor)** - Built in 1960, it was a 40 megawatt reactor. It was the second largest facility for production of radioisotopes in India. It was decommissioned on December 31, 2010.

iii. **Zerlina (Zero Energy Reactor for Lattice Investigation and New Assemblies)** - It was commissioned on January 4, 1961 and used for studies of uranium heavy water lattice.

iv. **Dhruva** – Commissioned on August 15, 1984, this 100 megawatt reactor is a completely indigenous nuclear reactor with most advanced laboratories in the world. It is the largest source of radioisotopes in India.

v. **Purnima – I (Plutonium Reactor for Neutronic Investigation in Multiplaying Assemblies)** - Commissioned on May 22, 1972, plutonium fuelled reactor, modified as Purnima-II that used uranium as fuel and it is being further modified as Purnima-III.

vi. **Kamini** - India's first fast breeder neutron reactor, it has been set up at Kalpakkam. Today India is the seventh country in the world and the first in developing nations to have mastered the fast breeder reactor technology.

INDIA'S THREE-STAGE NUCLEAR POWER PROGRAMME

India's three stage nuclear power programme was formulated by Dr. Homi Bhabha in the 1950s to secure the country's long term energy independence, through the use of uranium and thorium reserves found in the monazite sands of coastal regions of South India. The ultimate focus of the programme is on enabling the thorium reserves of India to be utilized in meeting the country's energy requirements. Thorium is particularly attractive for India, as it has only around 1-2% of the global uranium reserves, but one of the largest shares of global thorium reserves at about 30% of the total world thorium reserves.

Since the inception of the programme, India has built up its capacity in the area of nuclear research to the extent that it is now generally considered as the leader of thorium based research in the world. As of 2012, the first stage consisting of the PHWRs is near completion of its planned goals, the second stage consisting of fast breeder reactors is poised to go into operation within one year, and the third stage consisting of AHWRs is slated to begin construction so that its commissioning can be done by 2020.

RATIONALE

Dr. Homi Bhabha conceived of the three-stage nuclear programme as a way to develop nuclear energy by working around India's limited uranium resources. Thorium itself is not a fissile material, and thus cannot undergo fission to produce energy. Instead, it must first be converted into the fissile isotope uranium-233 by transmutation in a reactor fuelled by other fissile materials. The first two stages, natural uranium-fuelled heavy water reactors and plutonium-fuelled fast breeder reactors, are intended to generate sufficient fissile material from India's limited uranium resources, so that all its vast thorium reserves can be fully utilised in the third stage of thermal breeder reactors.

Stage I - Pressurised Heavy Water Reactor (PHWR)

In the first stage of the programme, natural uranium fuelled PHWR produce electricity while generating plutonium-239 as by-product. Heavy water is used as moderator and coolant. PHWRs was a natural choice for implementing the first stage because it had the most efficient reactor design in terms of uranium utilization, and the existing Indian infrastructure in the 1960s allowed for quick adoption of the PHWR technology. India correctly calculated that it would be easier to create heavy water production facilities (required for PHWRs) than uranium enrichment facilities (required for LWRs). The design, construction and the operation of these reactors are undertaken by public sector undertaking, NPCIL (Nuclear Power Corporation of India Limited).

Almost the entire existing base of Indian nuclear power (4780 MW) is composed of first stage PHWRs, with the exception of the two Boiling Water Reactor (BWR) units at Tarapur.

Stage II - Fast Breeder Reactor (FBR)

In the second stage, FBRs would use a mixed oxide (MOX) fuel made from plutonium-239, recovered by reprocessing spent fuel from the first stage, and natural uranium. In FBRs, plutonium-239 undergoes fission to produce energy, while the uranium-238 present in the mixed oxide fuel transmutes to additional plutonium-239. Thus, the Stage II FBRs are designed to "breed" more fuel than they consume. Once the inventory of plutonium-239 is built up thorium can be introduced as a blanket material in the reactor and transmuted to uranium-233 for use in the third stage.

The design of the country's first fast breeder, called Prototype Fast Breeder Reactor (PFBR), was done by Indira Gandhi Centre for Atomic Research (IGCAR). Bharatiya Nabhikiya Vidyut Nigam Ltd (Bhavini), a public sector company under the Department of Atomic Energy (DAE), has been given the responsibility to build the fast breeder reactors in India. The construction of this PFBR at Kalpakkam is due to be completed in 2012.

In addition, the country proposes to undertake the construction of four FBRs as part of the 12th Five Year Plan spanning 2012-17, thus targeting 2500 MW from the five reactors. One of these five reactors is planned to be operated with metallic fuel instead of oxide fuel, since the design will have the flexibility to accept metallic fuel, although the reference design is for oxide fuel. Indian government has already allotted Rs.250 crore for pre-project activities for two more 500 MW units, although the location is yet to be finalised.

Stage III - Thorium Based Reactors

A Stage III reactor or an Advanced nuclear power system involves a self-sustaining series of thorium-232-uranium-233 fuelled reactors. This would be a *thermal breeder reactor*, which in principle can be refuelled - after its initial fuel charge - using only naturally occurring thorium. The ongoing development of 300 Mwe advanced heavy water reactor (AHWR) at BARC concerns thorium utilization and its demonstration.

According to the three stage programme, Indian nuclear energy could grow to about 10 GW through PHWRs fuelled by domestic uranium, and the growth above that would have to come from FBRs till about 50GW. The third stage is to be deployed only after this capacity has been achieved.

ABOUT THORIUM

- Thorium (Atomic No– 90; Weight – 232) is a basic element of nature, like Iron and Uranium. Like Uranium, its properties allow it to be used to fuel a nuclear chain reaction that can run a power plant and make electricity (among other things).
- Thorium is extracted mostly from monazite: thorium diphosphate (Th(PO4)2), a reddish-brown phosphate mineral.
- Thorium itself will not split and release energy. Rather, when it is exposed to neutrons, it will undergo a series of nuclear reactions until it eventually emerges as an isotope of uranium called U-233, which will readily split and release energy next time it absorbs a neutron.
- Thorium is therefore called fertile, whereas U-233 is called fissile.
- Reactors that use thorium are operating on what's called the Thorium-Uranium (Th-U) fuel cycle. The vast majority of existing or proposed nuclear reactors, however, use enriched uranium (U-235) or reprocessed plutonium (Pu-239) as fuel (in the Uranium-Plutonium cycle), and only a handful have used thorium. Current and exotic designs can theoretically accommodate thorium.

THORIUM FUEL CYCLE

The **thorium fuel cycle** is a nuclear fuel cycle that uses the naturally abundant isotope of thorium, 232 Th, as the fertile material. In the reactor, 232 Th is transmuted into the fissile artificial uranium isotope 233 U which is the nuclear fuel.

$$ {}^{232}_{90}\mathrm{Th} + \mathrm{n} \rightarrow {}^{233}_{90}\mathrm{Th} + \gamma \xrightarrow{\beta^-} {}^{233}_{91}\mathrm{Pa} \xrightarrow{\beta^-} {}^{233}_{92}\mathrm{U} $$

Unlike natural uranium, natural thorium contains only trace amounts of fissile material (such as 231 Th), which are insufficient to initiate a nuclear chain reaction. Additional fissile material or another neutron source is necessary to initiate the fuel cycle. In a thorium-fuelled reactor, 232 Th absorbs neutrons eventually to produce 233 U. This parallels the process in uranium reactors whereby fertile 238U absorbs neutrons to form fissile 239 Pu. Depending on the design of the reactor and fuel cycle, the 233 U generated either fissions in situ or is chemically separated from the used nuclear fuel and formed into new nuclear fuel.

The thorium fuel cycle claims several potential advantages over a uranium fuel cycle, including thorium's greater abundance, superior physical and nuclear properties, better resistance to nuclear weapons proliferation, and reduced plutonium and actinide production.

Advantages of using Thorium as a nuclear fuel

Thorium is estimated to be about three to four times more abundant than uranium in the Earth's crust, although present knowledge of reserves is limited. Current demand for thorium has been satisfied as a by-product of rare-earth extraction from monazite sands.

Also, unlike uranium, mined thorium consists of a single isotope (232 Th). Consequently, it is useful in thermal reactors without the need for isotope separation.

Thorium-based fuels also display favourable physical and chemical properties which improve reactor and repository performance. Compared to the predominant reactor fuel, uranium dioxide (UO_2), thorium dioxide (ThO_2) has a higher melting point, higher thermal conductivity, and lower coefficient of thermal expansion. Thorium dioxide also exhibits greater chemical stability and, unlike uranium dioxide, does not further oxidize.

The long term radiological hazard of conventional uranium-based used nuclear fuel is dominated by plutonium and other minor actinides, after which long-lived fission products become significant contributors again.

Disadvantages of using Thorium as a nuclear fuel

There are several challenges to the application of thorium as a nuclear fuel, particularly for solid fuel reactors.

Unlike uranium, natural thorium contains no fissile isotopes; fissile material, generally 233 U, 235U, or plutonium, must be added to achieve criticality. This, along with the high sintering temperature necessary to make thorium-dioxide fuel, complicates fuel fabrication.

In an open fuel cycle (i.e. utilizing 233 U in situ), higher burn up is necessary to achieve a favourable neutron economy. Although thorium dioxide performed well at burn ups at Fort St. Vrain Generating Station and AVR respectively, challenges complicate achieving this in light water reactors (LWR), which compose the vast majority of existing power reactors.

Another challenge associated with a once-through thorium fuel cycle is the comparatively long interval over which 232 Th breeds to 233 U. The half-life of 233 Pa is about 27 days, which is an order of magnitude longer than the half-life of 239 Np. As a result, substantial 233 Pa develops in thorium-based fuels. 233 Pa is a significant neutron absorber, and although it eventually breeds into fissile 235 U, this requires two more neutron absorptions, which degrades neutron economy and increases the likelihood of trans-uranic production.

NUCLEAR VISION 2020 OF DAE

It envisages for establishing an installed capacity of 20,000 MW of nuclear power by year 2020 partly through indigenous technology and partly through import of nuclear reactors. The present nuclear power capacity in the country is 4780 MW.

FOREIGN INVESTMENT IN INDIA'S NUCLEAR SECTOR

India's civilian nuclear programme was largely indigenous for many years, but the government is now beckoning foreign investment. It intends to set up 'nuclear parks' supplied by foreign companies and operated - for now - by the Nuclear Power Corporation of India Limited (NPCIL), a government-owned company. These parks are planned to have installed generated capacity of 8,000-10,000 MW at a single site. As the greatest installed capacity at one site is currently only 1,400 MW (Tarapur Atomic Power Station in Maharashtra, with four reactors), this is a huge increase.

Russian company Atomstroyexport, a government subsidiary, has reached a deal to build sixteen nuclear reactors in India. Two of these units, of 1000 MW each, are currently under construction in Kundankulam, Tamil Nadu, though are not yet operational. The first is already three years behind schedule.

French company AREVA NP (a joint venture between AREVA and Seimens) have agreed to construct six 1650 MW reactors in Jaitapur, Maharashtra. The European pressurized reactors, an untested type of reactor, will have a collective capacity of 9900 MW, making the Jaitapur nuclear power plant the largest in the world.

Private US companies GE-Hitachi Nuclear Energy and Westinghouse Electric have been given sites at Kovada in Andhra Pradesh and Mithivirdi in Gujarat, respectively.

RADIO – ISOTOPES

Radioisotopes are those isotopes of certain elements which are unstable and thus radioactive. For example, Iodine-131, Indium-192, Molybdenum-99, Chromium-51, Phosphorus-32. These are either man-made in nuclear reactor or found in nature.

APPLICATIONS

These are useful in the field of agriculture, medical diagnosis and treatment, water management and industries.

1. AGRICULTURE

In the field of agriculture radioisotopes are used for developing mutant crop varieties such as for rice, wheat, pulses etc which are hybrid varieties having high yield and resistant to various diseases. BARC in collaboration with agricultural universities has successfully developed various high yielding crop varieties of groundnut, pulses, rice etc for commercial cultivation. BARC has successfully developed green manure crop Sesbania Rostrata.

II. MEDICINE AND HEALTH CARE

Radio-isotopes such as Cobalt-60, Arsenic-74 are used in treating thyroid disorders and various types of cancer. BARC's Radiation medicine centre in Mumbai is involved in R&D in nuclear medicine. It offers diagnostic and therapeutic services using radioisotopes and promotes human resource development in nuclear medicine. Radioimmunoassays and related procedures are used for measurements of hormones, enzymes, certain serum proteins. Another important development is digital medical imaging system based on charge coupled device (CCD). For detection of disease infection of TB, BARC has developed sero-diagnostic test kit, X-ray imaging using a 3-D cone-beam tomography I another important development.

III. WATER MANAGEMENT

BARC has developed a number of desalination technologies for providing potable water in rural areas and on ships. These technologies are based on multistage flash evaporation reverse osmosis and low temperature evaporation.

IV. INDUSTRY

In the field of industry, radio-isotopes are used for food irradiation, quality control of industrial products and testing of sub-systems.

V. FOOD IRRADIATION

It is a method of food preservation which involves exposing food to ionising radiation up to 10Mn eV. When the food items are subjected to radiation, electrons are knocked off from atoms and molecules, thereby breaking the chemical bonds and thus destroying enzymes needed for the cellular functions. The substances that are normally used for food irradiation are Cobalt-60, X-rays, high energy electrons. The Indian Parliament in 1994 amended the Prevention of Food Adulteration Act and provided for irradiation of spices, potatoes, onions and other tubers. BARC in 1999 established a spice irradiation centre at Vashi near Bombay. The department of atomic energy in 2001 established POTON (irradiating centre for potato and onion) near Nasik in Maharashtra.

POTENTIAL USES

1. It kills bacteria and other microbes found in the food stuff. Thus, it helps in increasing shelf life of certain food items.
2. By disturbing the cellular function in tubers such as potato and onion, it prevents the sprouting of potato and onion in storage.
3. It can also help in avoiding use of harmful chemicals such as methyl bromide.
4. Food can be irradiated in packed condition and thus contamination of food during packaging can be avoided.

LIMITATIONS

1. Irradiation can destroy bacteria but cannot neutralize toxins produced by bacteria in food stuff.
2. It may also create artificial flavours and taste in certain items. It may also destroy the vitamins.

3. It also involves establishment of sophisticated and costly equipment therefore small and medium scale industries may not have access to such facilities.
4. It also requires strict regulations by government because of health hazards that may be caused due to over exposure to irradiation.

CHAPTER – 4

DEFENCE PROGRAMME

QUESTIONS ASKED IN THE PREVIOUS YEARS

- What are the salient features of India' missile development programme? (1992/40M)
- Give an account of the achievements of Indian defence scientists in technology development. (1993/40M)
- How does the development of Pinaka benefit India? (1998/40M)
- Why is Agni Project important for India? (1997/40M)

INTRODUCTION

India's defence policy aims at promoting and sustaining durable peace in the subcontinent, while at the same time equipping the defence forces adequately to safeguard against any aggression.

Its long term military and strategic aims have been defined as –

1. Keeping the war machine i.e. the armed forces well trained and ready to wage war at short notice
2. Having a wide industrial base and infrastructure to support any long term insurgency or war when it is thrust upon us
3. Avoidance of conflict by acquisition of deterrents like nuclear weapons and their delivery systems

By its very nature and because of its sensitivity, defence is an area where it is wise to develop self-reliance. Modern defence systems are necessarily linked to scientific management. Science and technology builds and develops the defence hardware of a country and war and defence have become increasingly electronically controlled. In this scenario, India has also developed an impressive defence infrastructure, largely emphasizing on technological advancement aimed at achievement of self reliance.

MISSILES

TYPES OF MISSILES

I. BALLISTIC MISSILE

A ballistic missile is a missile that follows a sub-orbital ballistic flight path (moving under their own momentum and the force of gravity..similar to the Diwali rockets) with the objective of delivering one or more warheads to a predetermined target. The missile is only guided during the relatively brief initial powered phase of flight and its course is subsequently governed by the laws of orbital mechanics and ballistics. To date, ballistic missiles have been propelled during powered flight by chemical rocket engines of various types.

A ballistic missile trajectory consists of three parts: the powered flight portion, the free-flight portion which constitutes most of the flight time, and the re-entry phase where the missile re-enters the Earth's atmosphere. Ballistic missiles can be launched from fixed sites or mobile launchers, including vehicles (transporter erector launchers), aircraft, ships and submarines.

When in space and no more thrust is provided, the missile enters free-flight. In order to cover large distances, ballistic missiles are usually launched into a high sub-orbital spaceflight; for intercontinental missiles the highest altitude (apogee) reached during free-flight is about 1200 km.

Ballistic missiles are categorised according to their range- the maximum distance measured along the surface of earth's ellipsoid from the point of launch to the point of impact of the last element of their payload. The missile can carry a huge payload.

For example, Prithvi, Agni and Dhanush ballistic missiles are currently operational in the Indian defence forces.

Based on their range, Ballistic Missiles can be classifies as:

1. **Short range ballistic missiles:** < 1000 km. Example: Prithvi
2. **Medium range ballistic missiles:** 1000-3000 km. Example: Shaurya
3. **Intermediate range ballistic missiles:** 3000-5500 km. Example: Agni I-IV
4. **Intercontinental ballistic missiles:** > 5500 km. Example: Agni V

MIRV: A separate category of ballistic missile are the MIRVs (Multiple Independent Re-entry Vehicles): MIRV is a ballistic missile payload containing several warheads, each capable of being aimed to hit one of a group of targets. Basically in the last stage, the payload released multiple smaller missiles. By increasing the numbers of warheads per missile, MIRVs are in a better position to penetrate defenses and simultaneously strike diverse targets. MIRVs make it difficult for the missile defence systems as they have to track and neutralise multiple missiles at once.

II. CRUISE MISSILE

A cruise missile is a guided missile that carries an explosive payload and is propelled, usually by a jet engine, towards a land-based or sea-based target. Cruise missiles are designed to deliver a warhead over long distances with high accuracy. Modern cruise missiles can travel at supersonic or high subsonic speeds, are self-navigating, and can fly on a non-ballistic, extremely low altitude trajectory. In a cruise missile, the warhead is integrated into the vehicle and the vehicle is always sacrificed in the mission.

While ballistic missiles were the preferred weapons for land targets, heavy nuclear and conventional tipped cruise missiles were seen by the USSR as a primary weapon to destroy US naval carrier battle groups.

Cruise missiles can be categorised by size, speed (subsonic or supersonic), range and whether launched from land, air, surface ship or submarine.Example are Nirbhay and Brahmos.

Depending upon the speed such missiles are classified as:

- **Subsonic cruise missile** (less than the speed of sound) Example: Nirbhay
- **Supersonic cruise missile** (2-3 times the speed of sound) Example: Brahmos
- **Hypersonic cruise missile** (5 times the speed of sound) Example: Brahmos-II

MAJOR MISSLES CATEGORIES BASED ON LAUNCH MODE

(i) Surface-to-Surface Missile: These missiles are launched from vehicle mounted, trailer mounted or fixed installations. Example: Prithvi, Agni

(ii) Surface-to-Air Missile: These missiles are launched from the ground to destroy aerial targets like aircrafts, helicopters and even ballistic missiles. These missiles are generally called air defence systems as they defend any aerial attacks by the enemy. Example: Akash, Trishul

(iii) Surface(Coast)-to-Sea Missile: These missiles are launched from land to target ships at sea.

(iv) Air-to-Air Missile: These missiles are launched from an aircraft to destroy the enemy aircraft. Example: Astra

(v) Air-to-Surface Missile: These missiles are launched from military aircraft and strikes ground targets on land, at sea or both.

(vi) Sea-to-Sea Missile: These missiles are launched from ship to target another ship. Example: Dhanush

(vii) Sea-to-Surface (Coast) Missile: These missiles are launched from ship to land based targets. Example: Dhanush

(viii) Anti-Tank Missile: An anti-tank missile is a guided missile primarily designed to hit and destroy heavily-armoured tanks and other armoured fighting vehicles. Anti-tank missiles could be launched from aircraft, helicopters, tanks and also from shoulder mounted launcher. Example: Nag missile.

(ix) Submarine launched: These missiles are launched from submarines to target land based targets. Example: Sagarika/K-15

INTEGRATED GUIDED MISSILE DEVELOPMENT PROGRAM (IGMDP)

The IGMDP was an Indian Ministry of Defence program between 1983 and 2007 for the development of a comprehensive range of missiles, including the intermediate range Agni missile, and short range missiles such as the Prithvi ballistic missile, Akash missile, Trishul missile and Anti tank Nag Missile. The program was managed by Defence Research and Development Organization (DRDO) in partnership with other Indian government labs and research centres.

A committee headed by the then DRDO chief Dr. Raja Ramanna conceived this highly ambitious and challenging programme. The programme was conceived as a comprehensive missile development programme (MDP) consisting of five core missile systems having different strategic roles and capabilities.

India desired comprehensive and integrated capabilities in missile systems because while on one hand, they have the advantage of delivering higher pay load beyond the range of combat aircraft, on the other hand, they are one-way devices and there are no dangers associated as with loss of a combat aircraft and its crew. Moreover, with their high speed their interception is also more difficult than combat aircrafts.

The last major missile developed under the program was Agni III intermediate-range ballistic missile which was successfully tested on 9 July 2007. On 8 January 2008, the DRDO announced that it will be closing the IGMDP program formally since most of the missiles in the program have been developed and inducted into Indian armed forces. In 2008, India announced the closing of the strategic integrated guided missile development programme. The DRDO has independently continued further development work on Nag and Surya missiles. In addition, the DRDO is also developing a laser-based weapon system as part of its ballistic missile defence program to intercept and destroy missiles soon after they are launched towards the country.

The main aim of the Integrated Guided Missile Development Program was to design, develop, and operationalise missiles in five different categories simultaneously, namely

1. Short-range surface-to-surface missile - Prithvi
2. Intermediate-range surface-to-surface missile - Agni
3. Short-range surface-to-air missile - Trishul
4. Medium-range surface-to-air missile - Akash
5. Third-generation anti-tank guided missile - Nag

PRITHVI MISSILE SYSTEM

The Prithvi (in Sanskrit 'earth') missile is a family of tactical surface-to-surface short-range ballistic missiles (SRBM) developed by DRDO of India. The Prithvi was India's first indigenously developed ballistic missile. It was first test-fired in 1988. It has a range of up to 150 to 300 km. It can carry a payload of 500 kg up to 250 km and payload of 1000 Kg up to 150 km.

The land variant is called Prithvi while the naval operational variant of Prithvi I and Prithvi II class missiles are code named Dhanush. The submarine version is named Sagarika.

Developed as a battlefield missile, it could carry a nuclear warhead in its role as a tactical nuclear weapon.

VARIANTS OF PRITHVI

PRITHVI I

Prithvi I is a single stage liquid-fuelled surface-to-surface missile with a maximum warhead payload of 1,000 kg and a range of 150 km. It had an accuracy of 10 – 50 metres and was launched from transporter erector launchers. This class of Prithvi missiles was inducted into the Indian Army in 1994.

PRITHVI II

Prithvi II class is a single stage liquid-fuelled missile with maximum payload of 300 kg, but with an extended range of 250 kilometres. It was developed with the Indian Air Force being the primary user. It was first test-fired on January 27, 1996 and the development stages were completed in 2004. The Prithvi II class of missiles was inducted into the Army as well as the Air Force.

PRITHVI III

Prithvi III class is a solid fuelled version with a longer-range of 350 km. and was successfully test fired in 2004. It is a two stage, solid fuel, road-mobile, short range, surface to surface missile.

AGNI MISSILE SYSTEM

The Agni (in Sanskrit 'fire') missile is Intermediate range ballistic missiles (IRBM) which can have range up to 5000 km. It is a surface to surface missile. The initial Technology demonstrator version had a range of 1500 km but was based on a solid and a liquid stage making for long preparation before firing. Missiles of Agni series are developed by DRDO and manufactured by Bharat Dynamics Limited. It is a missile having a re-entry capability i.e. it propels itself out of the earth atmosphere and then re-enters and falls to the surface of the earth. It can carry both conventional and nuclear warheads and thus acts as both battlefield weapon and a deterrent. It is also called strategic missile as it can hit long-range targets.

The Agni-I, Agni-II, and Agni-III missiles were developed under the IGMDP. (The DRDO formally announced the successful completion of the IGMDP after the third test of Agni-III on May 7, 2008.)

AGNI-I

Agni-I, a single stage solid fuelled missile of 700–900 km range, was the first missile of the Agni family. It is both rail and road mobile. It can carry a nuclear payload of 1,000 kg.

AGNI-II

Agni-II a two and a half stage, solid fuelled missile with a range of 2000–3000 km, was tested on 11 April 1999 from a converted rail carriage. Being rail and road mobile significantly reduces it vulnerability to first strike. Later versions of Agni-II feature a manoeuvring re-entry. Agni-II can carry a nuclear payload of 1000 kg. It has been provided with global positioning system (GPS) that can help in making navigational corrections so that missile can hit its targets accurately. It was deployed by army in 2002.

AGNI-III

Agni-III is the third in the Agni series of missiles with two stage solid propulsion system and a striking range of 3500–5000 km. Agni-III was inducted in June 2011. It is one of the most sophisticated and accurate missiles in its range class. Agni-III reportedly has anti-ballistic missile countermeasures such as decoys and manoeuvring warhead.

AGNI-IV

It was earlier known as **Agni II+/Agni II Prime**. Agni-IV has a range of 3,000 km, and can take a warhead of 1 tonnes. It's a two-stage missile powered by solid propellant. The missile is under induction.

AGNI-V

A new missile Agni-V, an intercontinental ballistic missile with 5,000 km range and MIRV is being developed by DRDO. Agni-V shares the similar design as Agni-III with an extra stage added to further increase the range by 1500 km.

Agni-5 was successfully flight tested in December, 2016. This was the fourth test of Agni-5 missile and the second one from a canister on a road mobile launcher. All the four missions have been successful.

Agni-V missile will allow India to strike targets across Asia and into Europe, especially the east coast of China. The missile was designed to be easy to transport by road through the utilization of a canister-launch missile system which is distinct from those of the earlier Agni missiles. Agni-V would also carry MIRV (multiple independently targetable re-entry vehicles) payloads being concurrently developed.

With a canister-launch system to impart higher road mobility, the missile will give the armed forces much greater operational flexibility than the earlier-generation of Agni missiles.

TRISHUL MISSILE SYSTEM

Trishul is a short range surface-to-air missile (SAM) developed by India as a part of the Integrated Guided Missile Development Program. It has a range of 9 km and is fitted with a 5.5 kg warhead. Designed to be used against low-level targets at short range, the system has been developed to defend naval vessels against missiles and also as a short range surface to air missile on land. It has radar guided surveillance, tracking and guided mechanism for accurate interception of targets.

AKASH MISSILE SYSTEM

Akash (in Sanskrit 'sky') is a medium range surface-to-air missile (SAM) developed as part of India's IGMDP to achieve self-sufficiency in the area of surface-to-air missiles. It has an intercept range of 30 km. Akash flies at supersonic speed, reaching around Mach 2.5. It can reach an altitude of 18 km. A self-destruct device is also integrated. The missile has a terminal guidance system capable of working through electronic countermeasures. The entire Akash SAM system allows for attacking multiple targets. The Akash missile's use of ramjet propulsion system allows it to maintain its speed without deceleration. The missile is supported by multi-target and multi-function phased array fire control radar called the 'Rajendra' with a range of about 80 km in search, and 60 km in terms of engagement.

The missile is completely guided by the Radar, without any active guidance of its own. This allows it greater capability against jamming as the aircraft self protection jammer would have to work against the high power Rajendra, and the aircraft being attacked is not alerted by any terminal seeker on the Akash itself.

The launchers carry three ready-to-fire Akash missiles each. The launchers are automated, autonomous and networked to a command post and the guidance radar. The Akash system can be deployed by rail, road or air.

RAJENDRA RADAR

Rajendra is a radar developed by the RDO. It is multifunction radar, capable of surveillance, tracking and engaging low radar cross section targets. It is the heart of the Akash surface-to-air missile system and is the primary fire control sensor for an Akash battery. It is named after India's First president Dr. Rajendra Prasad.

It makes use of a passive phased array to search a volume of space, distinguish between hostile and friendly targets, automatically track up to 64 targets and command one of several launchers to engage up to 4 targets simultaneously.

NAG MISSILE SYSTEM

Nagis India's third generation anti-tank missile with a range of 3 to 7 km. It is all weather, top attack missile with fire and forget capability i.e. the target is sighted and it automatically aligns itself to the target. Nag uses Imaging Infra-Red (IIR) guidance with day and night capability. Nag can be mounted on an infantry vehicle.

Separate versions for the Army and the Air Force are being developed. For the Army, the missiles will be carried by specialist carrier vehicles (NAMICA-Nag Missile Carrier) equipped with a thermal imager for target acquisition. For the Air Force, a nose-mounted thermal imaging system has been developed for guiding the missile's trajectory. A variant of NAG missile to be launched from Helicopter is being developed under the Project named HELINA (HELIcopter launched NAg).

SHAURYA

The Shaurya missile (in Sankrit 'valour') is a short-range surface-to-surface ballistic missile developed by DRDO for use by the Indian Army. Capable of hypersonic speeds, it has a range of 600-700 km and is capable of carrying a payload of one-tonne conventional or nuclear warhead. The Shaurya missile provides India with a significant second strike capability. Shaurya missile is stored in a composite canister. It can remain hidden or camouflaged in underground silos from enemy surveillance or satellites till they are fired from the special storage-cum-launch canisters.

SAGARIKA

The *K-15 Sagarika* (in Sanskrit – wave/born from the ocean) missile is a nuclear capable submarine-launched variant of the Prithvi missile with a range of 700 km. Sagarika is a two-stage surface-to-surface missile for launch from submarines. The first stage is an underwater booster that powers the missile to 5 km above the surface of the ocean. A second solid-fuelled stage then propels the missile over 700 km. The development of the underwater missile launcher known as the Project 78 (P78) was completed in 2001. This was handed over to the Indian Navy for trials. It is being integrated with the Advanced Technology Vessel. Sagarika will form part of the **triad** in India's nuclear deterrence and will provide with retaliatory nuclear strike capability.

DHANUSH

Dhanush (in Sanskrit 'bow') is a ship-launched variant of the Prithvi missile. It can be used as an anti-ship weapon as well as for destroying land targets depending on the range.

LR-SAM

Long Range Surface-to-Air Missile (LRSAM) with a range of 70 km is a joint development programme of DRDO, Indian Navy and Israel Aerospace Industries (IAI. The missiles are intended to equip the three guided missile destroyers of the Indian Navy.

MR-SAM

Medium-Range Surface-to-Air Missile (MRSAM), developed by India and Israel for protecting territories and ground forces from air attacks. It boosts India's efforts to fill gaps in its air defence capabilities. The missile is similar to the Barak-8 missile used by the Navy's new destroyers. This supersonic missile system is designed to defend any type of airborne threat including aircraft and helicopters. It can intercept supersonic aircraft and even missiles. Earlier, a naval version of the same missile was tested in Israel. The system also includes a multi-functional surveillance and threat alert radar for tracking, detection and guidance of the missile.

ASTRA

India successfully test-fired a prototype of the Beyond Visual Range (BVR) air-to-air missile 'Astra'. BVR combat is increasingly becoming the norm in modern air warfare. As opposed to WVR (within visual range) combat, a BVR has the ability to detect, track and destroy the enemy aircraft much before they come in visual contact.

This brings India into a select group of nations possessing this vital military technology. The Astra missile is being developed indigenously to arm all fighters in the IAF, including the Light Combat Aircraft (LCA) when it becomes fully operational by around 2010.

Though Astra missiles with range of 25 to 40 km have been tested, defence scientists are looking at a 80 to 100 km "head-on" range.

INDIAN BALLISTIC MISSILE DEFENCE PROGRAMME

The Indian Ballistic Missile Defence Programme is an initiative to develop and deploy a multi-layered ballistic missile defence system to protect India from ballistic missile attacks. India began developing a multi-tiered Ballistic Missile Defense (BMD) system in 1999, after the end of the Kargil War in reaction to Pakistan's growing missile arsenal. A consortium of 40 Indian companies were involved in the development of the missile defense shield.

India's BMD shield is a two-tiered defense system:

1) **Prithvi Air Defense (PAD) / Pradyumna Ballistic Missile Interceptor** destroying missiles at exo-atmospheric altitudes of 50–80 kilometers (31–50 miles)
2) **Advanced Air Defense (AAD)/ Ashvin Advanced Defense interceptor** destroying missiles in endo-atmosphere at altitudes of 20-40 kilometers (12-24 miles).

In addition to the indigenously developed BMD system, India has procured six regiments of **Russian S-300 air defense systems** and is negotiating for five regiments of more advanced S-400 systems with Russia.

After the successful test of Ashwin, India became the fourth country in the world to have full-fledged multi-layer Ballistic Missile Defence system. Only United States, Russia and Israel are in the same league.

PAD was tested in November 2006, followed by AAD in December 2007. The deployed system would consist of many launch vehicles, radars, Launch Control Centres (LCC) and the Mission Control Centre (MCC). All these are geographically distributed and connected by a secure communication network.

The MCC is the software intensive system of the ballistic missile defence system. It receives information from various sources such as radars and satellites which is then processed by ten computers which run simultaneously. The MCC is connected to all other elements of the defence. MCC performs target classification, target assignment and kill assessment. It also acts as a decision support system for the commander. It can also decide the number of interceptors required for the target for an assured kill probability. After performing all these functions, the MCC assigns the target to the LCC of a launch battery. The LCC starts computing the time to launch the interceptor based upon information received from a radar based on the speed, altitude and flight path of the target. LCC prepares the missile for launch in real time and carries out ground guidance computation.

CRUISE MISSILES

BRAHMOS

The BrahMos is a short-range supersonic cruise missile, manufactured in a joint venture between India's Defence Research and Development Organisation (DRDO) and Russia's NPO Mashinostroeyenia who have together formed the BrahMos Aerospace Private Limited. The acronym BrahMos is perceived as the confluence of the two nations represented by two rivers, the Brahmaputra of India and the Moskva of Russia.

BrahMos has a flight range of up to 290km and can reach a maximum speed of Mach 3. The missile can be launched against ships and land-based targets. The missile can be installed on ships, submarines, aircraft and ground vehicles. The system has been inducted in two regiments of the Indian Army and eight warships of the Indian Navy. Air version of BrahMos Missile is currently in developmental stage

The development of this state-of-the-art missile is a reflection of the widening of the India-Russia defence relationship, a transformation from the routine buyer-seller track to a totally different level of military-technical cooperation. Under the agreement signed in

1998, India and Russia set up the joint missile venture and are equal partners in developing, manufacturing and marketing the missile. It is an example of how the India-Russia defence relationship now encompasses a wide range of activity that includes joint research, design, development and co-production.

Bharat Aeronautics Private Limited (BAPL) is contemplating a hypersonic Mach 7 version of the missile, named as the BrahMos II to boost aerial fast strike capability. BrahMos II will be the first hypersonic cruise missile and is expected to be ready for testing in early 2017.

NIRBHAY

Nirbhay (in Sanskrit 'Fearless') is India's indigenously designed and developed all-weather, long range, subsonic cruise missile. The missile is capable of flying at a tree-top altitude for over a range of over 1,000 km and will arm three services, the Indian Army, Indian Navy and the Indian Air Force. The Nirbhay can be launched from multiple platforms on land, sea and air. Nirbhay will be a terrain hugging, stealth missile capable of delivering different types of warheads depending on mission requirements and will use inertial navigation system for guidance. The missile supplements Brahmos by delivering warheads farther than the 290 km range of Brahmos.

SUBMARINES

TYPES OF SUBMARINES:

Submarines are classified based on how they are powered. Usually, there are two types:

1. **Diesel-Electric submarines:** These are conventional submarines that are powered by a combination of diesel engines and electric motor. India has INS Sindhughosh, INS Sindhuratna etc that are of this type.
2. **Nuclear powered submarines:** These are powered by a nuclear reactor. Being completely independent of need for air, these submarine need not come to the surface frequently, as is necessary for conventional submarines. They are also much bigger. India currently has only two - INS Arihant (built in India) and INS Chakra (leased from Russia).

Nuclear Submarines:

They are of two types:

1. **SSN - Submersible Ship (that is, submarine) Nuclear-powered:** These are the attack submarines or hunter-killer submarines. They are specifically designed for the purpose of attacking and sinking other submarines, surface combat ships and merchant vessels. These submarines do not carry long range missiles. The Indian navy envisaged multiple roles for the SSNs: two SSNs each to escort Aircraft carrier warships, protect the bases of the SSBNs and hunt enemy submarines in the Indian Ocean Region.
2. **SSBN - Submersible Ship (that is, submarine) Ballistic Nuclear-powered:** These are Submarines with the capability of deploying submarine-launched ballistic missiles (SLBMs) with nuclear warheads. They can fire missiles

thousands of kilometers from their targets.

SCORPENE SUBMARINES

Six Scorpene submarines are being built under P-75 by Mazgaon Docks Limited (MDL) with technology transfer from France. Scorpene submarines are advanced Diesel submarines with Air Independent Propulsion System (AIP) technology. Conventional diesel-electric submarines have to surface every few days to get oxygen, but with AIP systems, they can stay submerged for much longer periods. The state-of-art features of the Scorpene include superior stealth and the ability to use precision guided weapons. The attack can be launched with torpedoes, as well as tube launched anti-ship missiles, whilst underwater or on surface. It can undertake many types of missions typically undertaken by any modern submarine i.e Anti-Surface warfare, Anti-Submarine warfare, Intelligence gathering, Mine Laying etc. Kalvari is the first of the Scorpene submarines being built in India and has been inducted into the Indian Navy. Khanderi, India's second Scorpene submarine is all set for sea trials.

K FAMILY OF MISSILES

The K family of missiles is a series of submarine-launched ballistic missiles (SLBM) developed by India to boost its second-strike capabilities and thus the nuclear deterrence. Information about this family of missiles has mostly been kept classified. The indigenous "K" missiles are faster, lighter and stealthier.

K-15 / SAGARIKA MISSILE

The Sagarika K-15 missile is the SLBM variant of the Prithvi missile. This will also get help from Indian Regional Navigation Satellite System (IRNSS) to ensure guaranteed national access to precision navigation. These will enable high accuracy required for precision strike. (It has been discussed already above).

K-4 MISSILE

K-4, named after former President of India Dr. APJ Abdul Kalam, is the next significant development under the K-X series by DRDO. Details regarding the developments in this project are confidential and this project is sometimes referred to as "BLACK PROJECT" whose existence is neither denied nor acknowledged by DRDO.

K-4 is said to the submarine-launched version of either AGNI-III or AGNI-V. The goal of this project is to expand the second-strike options for the country. K-4 will provide India with the capability to target China and Pakistan simultaneously. INS Arihant, first of the Arihant Class Submarines, will be able to carry 4 (10m long) K-4s or 12 K-15s.The K-4 missile in its final version was successfully tested in 2014 from a simulated underwater.

3M-54 KLUB

The Russian 3M-54 Klub is an anti-submarine anti-ship cruise missile system with a range of 250 km-300 km with a maximum of 2.9 Mach. India has acquired around 200 3M-54 Klub for arming Talwar class frigate, Shivalik class frigate, Kolkata class destroyer and Sindhughosh class submarine.

VARUNASTRA

Varunastra is the first indigenous heavy-weight ship-launched anti-submarine electric torpedo, developed by DRDO. It has been handed over to Indian Navy. It is capable of targeting quiet and stealthy submarines, both in deep and littoral waters in intense counter measure environment. This torpedo has more than 95% indigenous content. The torpedo has advanced autonomous guidance algorithms with low drift navigational aids, insensitive warhead which can operate in various combat scenarios. It has GPS based locating aid, a unique feature in contemporary torpedoes in the world.

NUCLEAR TRIAD

Nuclear triad is the ability to deliver nuclear weapons from air, ground and water through bomber planes, intercontinental ballistic missiles (ICBMs), and submarine-launched ballistic missiles (SLBMs).

1. **Sea:** Nuclear-powered submarines INS Arihant (built in India) and INS Chakra (leased from Russia) provide us the ability to deliver nuclear weapons from deep seas (even of South China Sea).
2. **Land:** Agni Missiles provide us the ability to deliver nuclear missiles deep into China from the land.
3. **Air:** Rafale jets will significantly boost the capability to deliver nuclear missiles from air.

The purpose of having a three-branched nuclear capability is to significantly reduce the possibility that an enemy could destroy all of a nation's nuclear forces by striking first in an attack (called first-strike).

This, in turn, ensures that the attacked country can also retaliate with nuclear weapons (called second strike), and thus increases a nation's nuclear deterrence (that is, reduce the possibility of anyone attacking without fearing consequences).

OTHER DEVELOPMENTS:

TEJAS

Indigenously developed LCA is an advanced technology, supersonic, light weight, all-weather, multi-role fighter aircraft designed for multiple combat roles, developed by HAL, India. It is designed for air-to-air, air-to-ground and air-to-sea combat roles. It is the smallest, light-weight, fourth generation combat aircraft developed in the world. The Tejas achieved a speed of over 1,350 kilometres per hour (840 mph) during its sea level flight trials. IAF has approved induction of Tejas into operational service.

It is a tail-less, compound delta-wing design powered by a single engine. It came from the ***Light Combat Aircraft (LCA)*** programme, which began in the 1980s to replace India's ageing MiG-21 fighters. Later, the LCA was officially named "*Tejas*", meaning "Radiance" by then Prime Minister Atal Bihari Vajpayee.

DHRUV

Dhruv (in Sanskrit '*Polaris*') is a utility helicopter developed and manufactured by India's Hindustan Aeronautics Limited (HAL). Dhruv was first announced in November 1984. The ALH (advanced light helicopter) was designed with assistance from MBB in Germany. The Dhruv first flew in 1992; but development was prolonged due to multiple factors: the Indian Army's requirement alternations, budget restrictions, and sanctions placed on India following the 1998 Pokhran-II Indian nuclear testing.

The Dhruv entered into service in 2002. Dhruv is designed to meet the requirement of both military and civil operators. It is being supplied to the Indian Armed Forces along with a variant for civilian/commercial use. The helicopter was first exported to Nepal and Israel. It is on order by several other countries for both military and commercial uses.

NISHANT

The Nishant is an Unmanned Aerial Vehicle (UAV) developed by India's ADE (Aeronautical Development Establishment) a branch of DRDO for the Indian Armed Forces. The Nishant UAV is primarily tasked with intelligence gathering over enemy territory and also for reconnaissance, training, surveillance, target designation, artillery fire correction, damage assessment etc. The UAV has an endurance of 4.30 hours. It has completed development phase and user trials.

Nishant is one of the few UAVs in the world in its weight-class capable of being catapult-launched and recovered by using parachute, thus eliminating the need for a runway as in case of conventional take-off and landing with wheels.

UAV RUSTOM

The DRDO Rustom is a Medium Altitude Long Endurance (MALE) unmanned combat air vehicle (UCAV) being developed by DRDO for the three armed services. The aircraft has been named after Rustom Damania, a former professor of IISc, Bangalore. There will be three variants of the Rustom UAV:

1. Rustom-I: Tactical UAV with endurance of 12
2. Rustom-H: Larger UAV with flight endurance of over 24 hours (completely different design from Rustom-1), higher range and service ceiling than Rustom-1.
3. Rustom-II: An unmanned combat air vehicle based on Rustom-H model.

RUSTOM II / TAPAS 201

Heralding a new era in the indigenous development of UAVs, DRDO successfully carried out the maiden flight of TAPAS 201 (RUSTOM – II).

TAPAS 201, a multi-mission UAV is being developed to carry out the Intelligence, Surveillance and Reconnaissance (ISR) roles for the three Armed Forces with an endurance of 24 hours. It is capable to carry different combinations of payloads to perform missions during day and night. It is comparable to the American made Predator drone.

NAKSHATRA

Nakshatra is an integrated medium size aerostat surveillance system for surveillance, communications broadcasting, airborne early warning and detection of low flying aircrafts & missiles. Nakshatra consists of the aerostat (an unmanned airship filled with helium gas) and the surveillance system. Primarily developed for surveillance of sensitive borders such as the one with Pakistan, Nakshatra is a bigger variant of an earlier aerostat Akashdeep, with bigger payload capacity fitted with night vision infrared cameras and high resolution HD cameras. It will last for 14 days in air before the unmanned airship is refilled with helium gas.

LAKSHYA

Lakshya, Pilotless Target Aircraft (PTA) is a reusable aerial target system. Lakshya is remotely operated from ground to provide aerial target for training of gun and Missile crew and Air Defence pilots for all the three Services. The delivery of five Lakshya systems with 26 operational flights for Air Force have been accomplished in 2001-2002. The first batch of Lakshya has already been delivered to the Navy.

AEW&C SYSTEM

Airborne Early Warning and Control (AEW&C) System consists of sensors mounted on an aircraft, for locating and providing early warning to air and ground stations of airborne & sea surface targets. The first indigenous AEW&C System was handed over to IAF in early 2017. The AEW&C System is a system of systems populated with state-of-the art Active Electronically Scanned Radar (AESR), Secondary Surveillance Radar, Electronic and Communication Counter Measures, LOS (Line of Sight) and beyond LOS data link, voice communication system and self protection suite. The Airborne Surveillance System is a game changer in air warfare.

SUDARSHAN

India's first laser guided bomb, Sudarshan is the latest weapon system developed indigenously to occupy the niche of a precision delivery mechanism. It can be fitted to a 1000 pound gravity bomb and can guide it to the target using lasers with a CEP (Circular Error Probability) of 10 metres.

PINAKA MULTI BARREL ROCKET LAUNCHER

Pinaka is a multi-barrel rocket launch (MBRL) system used by the Indian Army. It is an indigenous.weapon system designed and developed by DRDO. The launcher vehicle of Pinaka carries two pods, housing a total of 12 rockets. The launch system can fire a salvo of 12 rockets within 40 seconds. The rockets can be fitted with wide range of warheads, including high explosive, anti-tank bomblet, anti-personnel mines etc. The system was used effectively in Kargil war, where it was successful in neutralizing enemy positions on the mountain tops. It has since been inducted into the Indian Army in large numbers.

The success of the guided Pinaka has reinforced the technological strength of the country in converting the unguided systems into weapons of high precision. India at present is operating two regiments of Pinaka.

PINAKA MK II

Pinaka mark-II rockets were recently successfully test-fired from the Integrated Test Range (ITR) at Chandipur in Odisha. While the earlier Pinaka version- Pinaka mark-I was an unguided rocket system, Pinaka mark-II is a guided version-, with a navigation, guidance and control kit. The conversion has helped in enhancing the accuracy and range of Pinaka. Pinaka-II has a range of more than 70 km (Pinaka-I has range of 40 km).

SMART ANTI AIRFIELD WEAPON (SAAW)

DRDO yesterday successfully flight tested the Smart Anti-Airfield Weapon (SAAW), from an Indian Air Force (IAF) aircraft. SAAW is an indigenously designed and developed is a light-weight high precision guided bomb. It is capable of engaging ground targets in a range of 100 kms from a fighter aircraft. Designed and developed by DRDO, this smart weapon can destroy even steel reinforced concrete runways and bunkers . It is used to make enemy airfields dysfunctional. Anti Airfield Weapon is a munition that can penetrate the concrete runways to make big crater which makes the runway unusable by the enemy fighter jets.

SAMYUKTA – ELECTRONIC WARFARE PROGRAMME FOR ARMY

This system is uniquely configured for the frequencies from high frequency to millimetre wave for reconnaissance, direction finding and position fixing, prioritizing and jamming of adversary's emissions. It is capable of handling both ground based and air borne threats. It has the capability to intercept, detect, search, identify and locate complex communication and radar signals. It monitors communication and radar activity across Forward Edge of the Battle area.

Samyukta was inducted in army in January 2004. With this achievement India has joined select band of nations which possess this kind of world class system.

It is a major step towards future electronic technologies. It will be used in the area of strategic electronics, strategic aeronautics and strategic astronautics. All these technologies would be for dual purpose. They will concurrently serve the economic development of the country.

DHVANI (DETECTION AND HIT VISUALIZATION USING ACOUSTIC N-WAVE IDENTIFICATION)

Council of Scientific and Industrial Research (CSIR) has developed state-of-the-art target training system - DHVANI - for shooters of the Indian Army. The sophisticated acoustic sensor-based indigenous system will help the Army develop shooting techniques for its combat personnel. The system will also help the Army personnel in perfecting marksmanship skills by accurately determining the location of bullet impact and providing real-time feedback during training. Paramilitary forces and sportspersons could also use the system for their target training exercises.

ADVANCED TOWED ARTILLERY GUN SYSTEM (ATAGS)

It is being developed by DRDO in collaboration with the private sector. ATAGS is a 155-mm towed (towed by another vehicle) artillery gun being developed in mission mode for the Army's artillery modernisation programme. With a firing range of 40 kms, the gun boasts of advanced features such as such as high mobility, quick deployability, auxiliary power mode, advanced communication system, and automated command and control system. An Army team had been involved in the project since the conceptual stage to overcome considerable differences that Army and the DRDO had on past project.

CHAPTER - 5

BIOTECHNOLOGY

Questions asked in the previous years:

1. What is genetic engineering? Why is it getting increasingly important these days? (1998/40M)
2. "Biotechnology boom may have a golden path for India." Discuss (2002/30M)
3. What is biotechnology? Discuss the important applications of Biotechnology. (2004/15M)
4. In what way 'medical biotechnology' and 'bioengineering' are useful for technological development of India? (2008/30M)
5. The human population is slated to grow to 9 billion by 2050. In this context many scientists predict that plant genomics would play a critical role in keeping out hunger and preserving the environment. Explain (2012/25M)
6. In the context of Assisted Reproductive Technologies, India has emerged as the hub of commercial surrogacy. What key biological, legal and ethical issues merit considerations while framing the regulation to govern surrogacy in India? (2012/10M)

INTRODUCTION – ORIGIN & PROCESS

Biotechnology refers to the application of various biological/living organisms and processes for the production of useful substances or effects in medicine, industry, agriculture. It includes various laboratory techniques, which enhance the usefulness of biological organisms and products to mankind.

The origins of biotechnology culminated with the birth of **genetic engineering**. There were two key events that have come to be seen as scientific breakthroughs beginning the era that would unite genetics with biotechnology.

1. One was the 1953 discovery of the structure of DNA, by Watson and Crick.
2. The other was the 1973 discovery by Cohen and Boyer of a recombinant DNA technique by which a section of DNA was cut from the plasmid of an E. coli bacterium and transferred into the DNA of another. This approach could, in principle, enable bacteria to adopt the genes and produce proteins of other organisms, including humans.

Popularly referred to as "genetic engineering," it came to be defined as the basis or tool of new biotechnology. The term "genetic engineering" was first coined by **Jack Williamson** in 1951.

Genetic engineering (also called **genetic modification)** is the direct human manipulation of an organism's genome using modern DNA technology. It involves the introduction of foreign DNA or synthetic genes into the organism of interest.

The most common form of genetic engineering involves the insertion of new genetic material at an unspecified location in the host genome. This is accomplished by isolating and copying the genetic material of interest using molecular cloning methods to generate a DNA sequence containing the required genetic elements for expression, and then inserting this construct into the host organism.

Genetic engineering alters the genetic makeup of an organism using techniques that introduce heritable material prepared outside the organism either directly into the host or into a cell that is then fused or hybridized with the host. This involves using recombinant nucleic acid (DNA or RNA) techniques to form new combinations of heritable genetic material followed by the incorporation of that material either indirectly through a vector system or directly through micro-injection, macro-injection and micro-encapsulation techniques.

An organism that is generated through the introduction of **recombinant DNA** is considered to be a genetically modified organism or transgenic organism. The first organisms genetically engineered were bacteria in 1973 and then mice in 1974. Insulin-producing bacteria were commercialized in 1982 and genetically modified food has been sold since 1994.

If genetic material from another species is added to the host, the resulting organism is called **transgenic**. If genetic material from the same species or a species that can naturally breed with the host is used the resulting organism is called **cisgenic**. Genetic engineering can also be used to remove genetic material from the target organism, creating a **gene knockout organism**.

BRANCHES OF BIOTECHNOLOGY

- Blue **biotechnology** is a term that has been used to describe the marine and aquatic applications of biotechnology, but its use is relatively rare.
- Green **biotechnology** is biotechnology applied to agricultural processes. **e.g.** selection and domestication of plants via micro-propagation, designing of transgenic plants to grow under specific environments in the presence (or absence) of chemicals. Green biotechnology might produce more environmentally friendly solutions than traditional industrial agriculture. **e.g.** engineering of a plant to express a pesticide, thereby ending the need of external application of pesticides, such as Bt corn.
- **Red biotechnology** is applied to medical processes. Some examples are the designing of organisms to produce antibiotics, and the engineering of genetic cures through genetic manipulation.
- **White biotechnology**, also known as industrial biotechnology. An example is the designing of an organism to produce a useful chemical. White biotechnology tends to consume less in resources than traditional processes used to produce industrial goods.

DEPARTMENT OF BIOTECHNOLOGY

In 1982, Government of India set up the National Biotechnology Board which was replaced by a separate **Department of Biotechnology (DBT), under the Ministry of Science and Technology** in 1986. The department has made significant achievements in the growth and application of biotechnology in the broad areas of agriculture, health care, animal sciences, environment, and industry. A unique feature of the department has been the deep involvement of the scientific community of the country through a number of technical task forces, advisory committees and individual experts in identification, formulation, implementation and monitoring of various programmes and activities.

APPLICATIONS OF BIOTECHNOLOGY

Biotechnology has applications in four major industrial areas, including

1. Health care (medical)
2. Crop production and agriculture
3. Non food (industrial) uses of crops and other products (e.g. biodegradable plastics, vegetable oil, biofuels)
4. Environmental uses

I. Applications In Medicine

1. Pharmacogenomics

It is the study of how the genetic inheritance of an individual affects his/her body's response to drugs. The vision of pharmacogenomics is to be able to design and produce drugs that are adapted to each person's genetic makeup.

2. Pharmaceutical Products

Most traditional pharmaceutical drugs are relatively simple molecules that have been found primarily through trial and error to treat the symptoms of a disease or illness. **Biopharmaceuticals** are large biological molecules such as proteins and these usually target the underlying mechanisms and pathways of a malady. They can deal with targets in humans that may not be accessible with traditional medicines.

Small molecules are manufactured by chemistry but larger molecules are created by living cells such as those found in the human body: for example, bacteria cells, yeast cells, animal or plant cells.

Modern biotechnology is often associated with the use of genetically altered microorganisms such as *E. coli* or yeast for the production of substances like synthetic insulin or antibiotics. It can also refer to transgenic animals or transgenic plants, such as Bt corn.

Biotechnology is also commonly associated with landmark breakthroughs in new medical therapies to treat hepatitis B, hepatitis C, cancers, arthritis, haemophilia, bone fractures, multiple sclerosis, and cardiovascular disorders. The biotechnology industry has also been instrumental in developing molecular diagnostic devices that can be used to define the target patient population for a given biopharmaceutical. Herceptin, for example, was the first drug approved for use with a matching diagnostic test and is used to treat breast cancer in women whose cancer cells express the protein HER2.

Modern biotechnology can be used to manufacture existing medicines relatively easily and cheaply. The first genetically engineered products were medicines designed to treat human diseases. To cite one example, in 1978 Genentech developed synthetic humanized insulin by joining its gene with a plasmid vector inserted into the bacterium *Escherichia coli*. Insulin, widely used for the treatment of diabetes, was previously extracted from the pancreas of abattoir animals (cattle and/or pigs). The resulting genetically engineered bacterium enabled the production of vast quantities of synthetic human insulin at relatively low cost.

3. Genetic Testing

Genetic testing involves the direct examination of the DNA molecule for mutated sequences.

4. Gene Therapy

Gene therapy may be used for treating, or even curing, genetic and acquired diseases like cancer and AIDS by using normal genes to supplement or replace defective genes or to bolster a normal function such as immunity.

II. Applications In Agriculture

1. Crop yield

Using the techniques of modern biotechnology, one or two genes may be transferred to a highly developed crop variety to impart a new character that would increase its yield.

2. Reduced vulnerability of crops to environmental stresses

Crops containing genes that will enable them to withstand biotic and abiotic stresses may be developed. For example, drought and excessively salty soil are two important limiting factors in crop productivity. Biotechnologists are studying plants that can cope with these extreme conditions in the hope of finding the genes that enable them to do so and eventually transferring these genes to the more desirable crops.

3. Increased nutritional qualities

Proteins in foods may be modified to increase their nutritional qualities. Proteins in legumes and cereals may be transformed to provide the amino acids needed by human beings for a balanced diet. For example, Golden rice.

4. Improved taste, texture or appearance of food

Modern biotechnology can be used to slow down the process of spoilage so that fruit can ripen longer on the plant and then be transported to the consumer with a still reasonable shelf life. This alters the taste, texture and appearance of the fruit. It could expand the market for farmers in developing countries due to the reduction in spoilage. For example, engineering soybeans to resist spoilage makes them less suitable for producing ***tempeh*** which is a significant source of protein that depends on fermentation.

5. Reduced dependence on fertilizers, pesticides and other agrochemicals

Most of the current commercial applications of modern biotechnology in agriculture are on reducing the dependence of farmers on agrochemicals. For example, *Bacillus thuringiensis* (Bt) is a soil bacterium that produces a protein with insecticidal qualities.

The lack of herbicides with broad-spectrum activity and no crop injury was a consistent limitation in crop weed management. The introduction of herbicide-tolerant crops has the potential of reducing the number of herbicide active ingredients used for weed management, reducing the number of herbicide applications made during a season and increasing yield due to improved weed management and less crop injury.

6. Production of novel substances in crop plants

Biotechnology is being applied for novel uses other than food. For example, oilseed can be modified to produce fatty acids for detergents, substitute fuels and petrochemicals. Potatoes, tomatoes, rice tobacco, lettuce, safflowers, and other plants have been genetically engineered to produce insulin and certain vaccines.

III. Bioremediation and Biodegradation

Biotechnology is being used to engineer and adapt organisms especially microorganisms in an effort to find sustainable ways to clean up contaminated environments. Biological processes play a major role in the removal of contaminants and biotechnology is taking advantage of the astonishing catabolic versatility of microorganisms to degrade/convert such compounds.

Marine environments are especially vulnerable since oil spills of coastal regions and the open sea are poorly containable and mitigation is difficult. Despite its toxicity, a considerable fraction of petroleum oil entering marine systems is eliminated by the hydrocarbon-degrading activities of microbial communities, in particular by a remarkable recently discovered group of specialists, the so-called **hydrocarbonoclastic bacteria (HCCB).**

IV. Animal Biotechnology

In animals, biotechnology techniques are being used to improve genetics and for pharmaceutical or industrial applications. Molecular biology techniques can help drive breeding programs by directing selection of superior animals. Animal cloning, through somatic cell nuclear transfer (SCNT), allows for genetic replication of selected animals. Genetic engineering, using recombinant DNA, alters the genetic makeup of the animal for selected purposes, including producing therapeutic proteins in cows and goats.

V. Industrial Biotechnology

Industrial biotechnology applies the techniques of modern molecular biology to improve the efficiency and reduce the environmental impacts of industrial processes like textile, paper and pulp; and chemical manufacturing. For example, industrial biotechnology companies develop biocatalysts, such as enzymes, to synthesize chemicals. Enzymes are proteins produced by all organisms. Using biotechnology, the desired enzyme can be manufactured in commercial quantities.

Commodity chemicals (e.g., polymer-grade acrylamide) and specialty chemicals can be produced using biotech applications. Using biocatalysts, the chemicals can be produced more economically and more environmentally friendly. An example would be the substitution of protease in detergents for other cleaning compounds. Detergent proteases, which remove protein impurities, are essential components of modern detergents. They are used to break down protein, starch, and fatty acids present on items being washed. Biotechnology also produces biotech-derived cotton that is warmer, stronger, has improved dye uptake and retention, enhanced absorbency, and wrinkle- and shrink-resistance.

BIOTECHNOLOGY FOR THE 21ST CENTURY

It is anticipated that the world's population in 2050 will be approximately 8.7 billion persons. The world's population is growing, but its surface area is not. Compounding the effects of population growth is the fact that most of the earth's ideal farming land is already being utilized. To avoid damaging environmentally sensitive areas, such as rain forests, we need to increase crop yields for land currently in use. By increasing crop yields, through the use of biotechnology the constant need to clear more land for growing food is reduced. Countries in Asia, Africa, and elsewhere are grappling with how to continue feeding a growing population. They are also trying to benefit more from their existing resources. Biotechnology holds the key to increasing the yield of staple crops by allowing farmers to reap bigger harvests from currently cultivated land, while preserving the land's ability to support continued farming.

Malnutrition in underdeveloped countries is also being combated with biotechnology. Rice breeders are using biotechnology to build Vitamin A into the rice. A second phase of the project will increase the iron content in rice to combat anaemia, which is widespread problem among women and children in underdeveloped countries. Golden rice, expected to be for sale in Asia in less than five years, will offer dramatic improvements in nutrition and health for millions of people, with little additional costs to consumers. Increased crop yield, greater flexibility in growing environments, less use of chemical pesticides and improved nutritional content make agricultural biotechnology, quite literally, the future of the world's food supply.

BIOTECHNOLOGY REGULATORY AUTHORITY OF INDIA BILL 2013

IMPORTANT PROVISIONS

- The Bill sets up an independent authority, the Biotechnology Regulatory Authority of India (BRAI), to regulate organisms and products of modern biotechnology.
- BRAI will regulate the research, transport, import, containment, environmental release, manufacture, and use of biotechnology products.
- Regulatory approval by BRAI will be granted through a multi-level process of assessment undertaken by scientific experts.
- BRAI will certify that the product developed is safe for its intended use. All other laws governing the product will continue to apply.
- A Biotechnology Regulatory Appellate Tribunal will hear civil cases that involve a substantial question relating to modern biotechnology and hear appeals on the decisions and orders of BRAI.

- Penalties are specified for providing false information to BRAI, conducting unapproved field trials, obstructing or impersonating an officer of BRAI and for contravening any other provisions of the Bill.

KEY ISSUES AND ANALYSIS

- The Tribunal has jurisdiction over a 'substantial question relating to modern biotechnology'. However, the Bill does not define this term. Leaving a term undefined could allow for flexibility but could also increase ambiguity.
- The Tribunal will consist of one judicial member and five technical members. This is not in conformity with a Supreme Court decision that the number of technical members on a bench of a Tribunal cannot exceed the number of judicial members.
- The Tribunal's technical members shall be eminent scientists or government officials with experience in the field. It is unclear whether the technical expertise of the latter can be equated with the former.
- The Bill does not specify any liability for damage caused by a product of biotechnology. Therefore, it will remain open to the courts to determine liability arising out of any adverse impact of modern biotechnology.
- Various committees have recommended that an autonomous statutory regulator having members with expertise in biotechnology be set up.

TRANSGENIC ORGANISMS

QUESTIONS ASKED IN THE PREVIOUS YEARS:

1. What are transgenic organisms? What are they used for? (1996/20M)
2. Why are transgenic organisms important? (1998/3M)
3. How are transgenic plants different from Hybrid plants and what is their relevance in modern agriculture? Elaborate (2000/15M)

What are transgenic organisms?

These are organisms in to the DNA of which a desirable gene from another species has been inserted by recombinant DNA technology. Thus, these organisms have the ability to produce special protein molecules of choice.

The aim of scientists is to transfer desirable characteristics from one organism to another, for example, to make a crop resistant to an herbicide or to enhance food value.

ADVANTAGES

1. Transgenic animals

- Transgenic cow for higher milk yield can be developed by activating the casein, the milk protein gene.
- Transgenic sheep for higher wool yield can be developed by activating the keratin, the hair protein gene.

- Transgenic fish that grows larger in size can be developed by activating the all fish growth regulator gene.

2. **Transgenic bacteria** with human genes have been produced that are used to manufacture useful pharmaceuticals such as human insulin, human growth hormone. The hormones produced by transgenic bacteria are much purer, safer and cheaper than earlier ones obtained from animal sources.

3. **Genetically modified crops (GM crops):**

- **Bt. Crops:** *Bacillus thuringiensis (BT)* is a poisonous soil bacterium that produces the BT toxin. If the Bt toxin gene is carried to the crops, they produce the BT toxin and when the pests try to attack them, they die due to the toxin. Thus such crops are pest resistant. Eg: Bt cotton, Bt Brinjal, etc.
- **Transgenic rice(Golden rice)** containing gene for **beta-carotene (Golden rice)** have been developed that helps in reducing the incidence of vitamin A deficiency.
- **Transgenic potato** containing gene for protein from Amaranthus grain have been developed that can improve the nutritional status of population, who are vegetarian.
- **Super rice:** A rice plant in to which gene for Iron and zinc absorption is introduced. Such plants can absorb more iron and zinc from the soil and are therefore more nutritious.
- **Electricity freelight:** A plant in to which bioluminescence gene is added so that the plant can glow without electricity.
- **Sweet corn:** The regular corn plant in to which Amylase gene is added produces the enzyme, amylase that breaks down its starch to glucose so that the corn is sweeter in taste and softer in texture.
- **Food vaccines:** A rice plant in to which the rota viral antibody gene is introduced can act as a food vaccine for the rota viral infection.

Some doubts have been raised as to the long-term impact of these organisms on human health & environment. There is apprehension that indiscriminate release of transgenic organisms may have adverse effect on indigenous varieties of crop in the long term, reducing their genetic diversity.

RELATED TERMS:

- **Transgenic Animals** – Animals that have had their DNA manipulated to possess and express an extra gene are known as transgenic animals.
- **Transgenic Plant:** Genetically engineered plant or offspring of genetically engineered plants. Transgenic plants result from the insertion of genetic material from another organism so that the plant will exhibit a desired trait. Recombinant DNA techniques are usually used.
- **Hybrid Plant:** It is the offspring of two parents that differ in one or more inheritable characteristics, especially the offspring of two different varieties of the same species or the offspring of two parents belonging to different species. They show qualities of two or more different types of plants combined by hybridisation.

It may be generally by cross pollination. For example, if you genetically alter plant A and plant B so that their genes mix together, you would create seeds in the fruit of the plants which will create plant C. These plants help to increase food production and are drought resistible, immune from pest-insects and various diseases. On the other hand, Transgenic Plants are genetic engineered plants or off spring of them. They usually contain material from at least one unrelated organism as from virus animal, or other plant. They are produced to include better qualities of such other organism. Combination of qualities of different organism is seen in the transgenic plants.

BIOLOGICAL ENGINEERING

Biological engineering, **biotechnological engineering** or **bioengineering** (including **biological systems engineering**) is the application of concepts and methods of biology and secondarily of physics, chemistry, mathematics and computer science to solve problems in life sciences, using engineering's own analytical and synthetic methodologies. The word bioengineering was coined by British scientist and broadcaster Heinz Wolff in 1954.

In this context, while traditional engineering applies physical and mathematical sciences to analyze, design and manufacture inanimate tools, structures and processes, biological engineering uses primarily the rapidly-developing body of knowledge known as molecular biology to study and advance applications of living organisms.

Biomedical engineers are specifically focused on applying biological and other sciences toward medical innovations, whereas biological engineers are focused principally on applying biology - but not necessarily to medical uses.

An important application of bioengineering is the analysis and cost-effective solution of problems related to human health, but the field is much more general than that. For example, **biomimetics** is a branch of biological engineering which strives to find ways in which the structures and functions of living organisms can be used as models for the design and engineering of materials and machines.

Although engineered biological systems have been used to manipulate information, construct materials, process chemicals, produce energy, provide food, and help maintain or enhance human health and our environment, our ability to quickly and reliably engineer biological systems that behave as expected is at present less well developed than our mastery over mechanical and electrical systems.

GENETIC TESTING

Genetic testing involves the direct examination of the DNA molecule itself. A scientist scans a patient's DNA sample for mutated sequences.

TYPES OF GENETIC TESTING

There are two major types of gene tests:

1. **In the first type,** a researcher may design short pieces of DNA ("probes") whose sequences are complementary to the mutated sequences. These probes will seek their complement among the base pairs of an individual's genome. If the

mutated sequence is present in the patient's genome, the probe will bind to it and flag the mutation.

2. **In the second type**, a researcher may conduct the gene test by comparing the sequence of DNA bases in a patient's gene to disease in healthy individuals or their progeny.

ADVANTAGES OF GENETIC TESTING

- Carrier screening, or the identification of unaffected individuals who carry one copy of a gene for a disease that requires two copies for the disease to manifest
- Determining sex
- Forensic/identity testing
- Newborn screening
- Prenatal diagnostic screening
- Pre-symptomatic testing for estimating the risk of developing adult-onset cancers
- Pre-symptomatic testing for predicting adult-onset disorders

DISADVANTAGES OF GENETIC TESTING

The absence of privacy and anti-discrimination legal protections in most countries can lead to discrimination in employment or insurance or other use of personal genetic information. This raises questions such as whether genetic privacy is different from medical privacy.

1. **Reproductive issues**: These include the use of genetic information in reproductive decision-making and the possibility of genetically altering reproductive cells that may be passed on to future generations. For example, germline therapy changes the genetic make-up of an individual's descendants. Thus, any error in technology or judgment may have far-reaching consequences. Ethical issues like designed babies and human cloning have also given rise to controversies between and among scientists and bioethicists, especially in the light of past abuses with eugenics.
2. **Effects on social institutions:** Genetic tests reveal information about individuals and their families. Thus, test results can affect the dynamics within social institutions, particularly the family.
3. Conceptual and philosophical implications regarding human responsibility, free will vis-à-vis genetic determinism and the concepts of health and disease.

GENE THERAPY

Gene therapy may be used for treating, or even curing, genetic and acquired diseases like cancer and AIDS by using normal genes to supplement or replace defective genes or to bolster a normal function such as immunity. It can be used to target somatic cells (i.e., those of the body) or gametes (i.e., egg and sperm) cells. In **somatic gene therapy**, the genome of the recipient is changed, but this change is not passed along to the next generation. In contrast, in **germline gene therapy**, the egg and sperm cells of the parents are changed for the purpose of passing on the changes to their offspring. There are basically two ways of implementing a gene therapy treatment:

1. **Ex vivo** (outside the body): Cells from the patient's blood or bone marrow are removed and grown in the laboratory. They are then exposed to a virus carrying the desired gene. The virus enters the cells, and the desired gene becomes part of the DNA of the cells. The cells are allowed to grow in the laboratory before being returned to the patient by injection into a vein.
2. **In vivo** (inside the body): The vectors are used to deliver the desired gene to cells in the patient's body.

CONCERNS REGARDING GENE THERAPY

1. **Gene delivery tools:** Genes are inserted into the body using gene carriers called vectors. The most common vectors now are viruses, which have evolved a way of encapsulating and delivering their genes to human cells. Scientists manipulate the genome of the virus by removing the disease-causing genes and inserting the therapeutic genes. However, while viruses are effective, they can introduce problems like toxicity, immune and inflammatory responses and gene control and targeting issues.
2. **High costs:** Since gene therapy is relatively new and at an experimental stage, it is an expensive treatment to undertake.
3. **Limited knowledge of the functions of genes:** Scientists currently know the functions of only a few genes. Hence, gene therapy can address only some genes that cause a particular disease. Worse, it is not known exactly whether genes have more than one function, which creates uncertainty as to whether replacing such genes is indeed desirable.
4. **Multigene disorders and effect of environment:** Most genetic disorders involve more than one gene. Moreover, most diseases involve the interaction of several genes and the environment. For example, many people with cancer not only inherit the disease gene for the disorder, but may have also failed to inherit specific tumour suppressor genes. Diet, exercise, smoking and other environmental factors may have also contributed to their disease.

PHARMACOGENOMICS

Pharmacogenomics is the study of how the genetic inheritance of an individual affects his/her body's response to drugs. The vision of pharmacogenomics is to be able to design and produce drugs that are adapted to each person's genetic makeup.

ADVANTAGES OF PHARMACOGENOMICS

Pharmacogenomics results in the following benefits:

1. **Development of tailor-made medicines:** Using pharmacogenomics, pharmaceutical companies can create drugs based on the proteins, enzymes and RNA molecules that are associated with specific genes and diseases. These tailor-made drugs promise not only to maximize therapeutic effects but also to decrease damage to nearby healthy cells.
2. **More accurate methods of determining appropriate drug dosages:** Knowing a patient's genetics will enable doctors to determine how well his/ her body can

process and metabolize a medicine. This will maximize the value of the medicine and decrease the likelihood of overdose.

3. **Improvements in the drug discovery and approval process:** Genes have been associated with numerous diseases and disorders. With modern biotechnology, these genes can be used as targets for the development of effective new therapies, which could significantly shorten the drug discovery process.
4. Better vaccines: Safer vaccines can be designed and produced by organisms transformed by means of genetic engineering. These vaccines will elicit the immune response without the attendant risks of infection.

Expected Questions:

1. What do you understand by genetic testing? Discuss its uses and limitations.
2. Explain the concept of biological engineering. Outline its important fields.
3. What are the important apprehensions in the use of gene therapy for treating various diseases?
4. Pharmacogenomics and its uses

HUMAN GENETIC ENGINEERING

Human genetic engineering is the alteration of an individual's genotype with the aim of choosing the phenotype of a newborn or changing the existing phenotype of a child or adult. It holds the promise of curing genetic diseases like cystic fibrosis and increasing the immunity of people to viruses.

BACKGROUND

Gene therapy trials on humans began in 2004 on patients with Severe Combined Immunodeficiency (SCID). The first gene therapy "success" resulted in SCID patients with a functional immune system. These trials were stopped when it was discovered that two of ten patients in one trial had developed leukaemia (a type of blood cancer) resulting from the insertion of the gene-carrying retrovirus near an oncogene. In 2007, four of the ten patients had developed leukaemia. Work is now focusing on correcting the gene without triggering an oncogene (Gene causing cancer). Human genetic engineering is already being used on a small scale to allow infertile women with genetic defects in their mitochondria to have children. Recently, United Kingdom has legalised it.

ETHICAL ISSUES

The issues range from a belief that every foetus has an inherent right to remain genetically unmodified to a belief that parents hold the rights to change their unborn children. In the middle is the belief that every child has the right to be born free from preventable diseases.

Wealthy families will opt to design their child with genetic advantages because other families are doing so, and everybody wants to provide their newborn child with the best opportunities in life. The use of germline gene therapy will mean wealthy families pass down enhanced traits to their children, potentially disadvantaging poorer families that cannot afford the technology.

CLONING

QUESTIONS ASKED IN THE PREVIOUS YEARS:

1. What is tissue culture? (1997/3M)
2. What is human cloning? Is it dangerous or beneficial? Discuss (2002/15M)
3. What is the therapeutic cloning? Describe briefly the method and its potential applications. (2005/15M)

CLONING means making an identical copy of the clones (a plant or animal specimen) – **physically as well as genetically**. Clones are exact replica of plants or animals, replicated **asexually**. A clone derives its genetic matter from a single parent. Cloning involves the removal of the nucleus from one cell and its placement in an unfertilized egg cell whose nucleus has either been deactivated or removed. It was British biologist, **J.B.S Haldane** (1963) who for the first time theorized that it would be possible to produce **genetic duplicates** from all living organisms includes human beings.

MOLECULAR CLONING

Molecular cloning refers to the process of making multiple molecules. Cloning is commonly used to amplify DNA fragments containing whole genes, but it can also be used to amplify any DNA sequence such as promoters, non-coding sequences and randomly fragmented DNA. It is used in a wide array of biological experiments and practical applications ranging from genetic fingerprinting to large scale protein production. Cloning of any DNA fragment essentially involves four steps:

1. Fragmentation - breaking apart a strand of DNA
2. **Ligation** - gluing together pieces of DNA in a desired sequence
3. **Transfection** - inserting the newly formed pieces of DNA into cells
4. **Screening/selection** - selecting out the cells that were successfully transfected with the new DNA

Initially, the required DNA needs to be isolated to provide a DNA segment of suitable size. Subsequently, a ligation procedure is used where the amplified fragment is inserted into a vector (piece of DNA). The vector (which is frequently circular) is linearised using restriction enzymes, and incubated with the fragment of interest under appropriate conditions with an enzyme called DNA ligase. Following ligation the vector with the insert of interest is transfected into cells. Finally, the transfected cells are cultured.

ANIMAL CLONING

Since 1990s, animal cloning has become a possibility. **Dolly, a sheep** was the first mammal to be produced through cloning method by a team of scientists led by Dr.Ian Wilmut at Roslin Institute, Edinburgh, UK in February 1997, through **nuclear transfer technology.**

HUMAN CLONING

Human cloning is the creation of a genetically identical copy of an existing or previously existing human. The term is generally used to refer to *artificial* human cloning. There are two commonly discussed types of human cloning: therapeutic and reproductive cloning.

Reproductive Cloning is method of delivering a baby by transferring nucleus of an adult human somatic cell to an enucleated human egg cell and allowing the manipulated egg (cloned zygote) cell to grow normally in the uterus of a surrogate mother. The child so born will be genetically identical to the adult human whose somatic cell nucleus is taken.

. **Therapeutic Cloning** is the method of using stem cells from the cloned human embryo to produce human organs and replacement tissues for medical purposes.

A third type of cloning called **replacement cloning** is a theoretical possibility, and would be a combination of therapeutic and reproductive cloning. Replacement cloning would entail the replacement of an extensively damaged, failed, or failing body through cloning followed by whole or partial brain transplant.

The first hybrid human clone was created in November 1998, by Advanced Cell Technologies. It was created from a man's leg cell, and a cow's egg whose DNA was removed. It was destroyed after 12 days. Since a normal embryo implants at 14 days, Dr Robert Lanza, ACT's director of tissue engineering, told the Daily Mail newspaper that the embryo could not be seen as a person before 14 days.

On January, 2008, Wood and Andrew French, Stemagen's chief scientific officer in California, announced that they successfully created the first 5 mature human embryos using DNA from adult skin cells, aiming to provide a source of viable embryonic stem cells. Dr. Samuel Wood and a colleague donated skin cells, and DNA from those cells was transferred to human eggs. It is not clear if the embryos produced would have been capable of further development.

CLONING IN STEM CELL RESEARCH

Somatic cell nuclear transfer (SCNT) is used to create embryos for research or therapeutic purposes. The most likely purpose for this is to produce embryos for use in stem cell research. This process is also called "research cloning" or "therapeutic cloning." The goal is not to create cloned human beings (called "reproductive cloning"), but rather to harvest stem cells that can be used to study human development and to potentially treat disease. While a clonal human blastocyst has been created, stem cell lines are yet to be isolated from a clonal source.

Therapeutic cloning is achieved by creating embryonic stem cells in the hopes of treating diseases such as diabetes and Alzheimer's. The process begins by taking out the nucleus that contains the DNA from an egg and putting it in a nucleus from an adult. In the case of someone with Alzheimer's disease, the nucleus from a skin cell of that patient is placed into an empty egg. The reprogrammed cell begins to develop into an embryo because the egg reacts with the transferred nucleus. The embryo will become genetically identical to the patient. The embryo will then form a blastocyst which has the potential to form/become any cell in the body.

SCNT PROCESS

The process of cloning a particular farm animal using SCNT is relatively the same for all animals. The first step is to collect the somatic cells from the animal that will be cloned. The somatic cells could be used immediately or stored in the laboratory for later use.

APPLICATIONS OF SCNT

SCNT is seen to be a great method for producing agriculture animals for food consumption. It successfully cloned sheep, cattle, goats, and pigs. Another benefit is SCNT is seen as a solution to clone endangered species that are on the verge of going extinct.

LIMITATIONS OF SCNT

Stresses placed on both the egg cell and the introduced nucleus are enormous, leading to a high loss in resulting cells. For example, Dolly the sheep was born after 277 eggs were used for SCNT, which created 29 viable embryos. Only three of these embryos survived until birth, and only one survived to adulthood.

In SCNT, not all of the donor cell's genetic information is transferred, as the donor cell's mitochondria that contain their own mitochondrial DNA are left behind. The resulting hybrid cells retain those mitochondrial structures which originally belonged to the egg. As a consequence, clones such as Dolly that are born from SCNT are not perfect copies of the donor of the nucleus.

REPRODUCTIVE CLONING

It is also known as Organism cloning and refers to the procedure of creating a new multi-cellular organism, genetically identical to another. In essence this form of cloning is an asexual method of reproduction, where fertilization or inter-gamete contact does not take place. Asexual reproduction is a naturally occurring phenomenon in many species, including most plants and some insects. Scientists have made some major achievements with cloning, including the asexual reproduction of sheep and cows. There is a lot of ethical debate over whether or not cloning should be used. However, cloning, or asexual propagation, has been common practice in the horticultural world for hundreds of years.

METHODS

Reproductive cloning generally uses "somatic cell nuclear transfer" (SCNT) to create animals that are genetically identical. This process entails the transfer of a nucleus from a donor adult cell (somatic cell) to an egg that has no nucleus. If the egg begins to divide normally it is transferred into the uterus of the surrogate mother. Such clones are not strictly identical since the somatic cells may contain mutations in their nuclear DNA. Additionally, the mitochondria in the cytoplasm also contains DNA and during SCNT this DNA is wholly from the donor egg, thus the mitochondrial genome is not the same as that of the nucleus donor cell from which it was produced. This may have important implications for cross-species nuclear transfer in which nuclear-mitochondrial incompatibilities may lead to death.

Artificial *embryo splitting* or *embryo twinning* may also be used as a method of cloning, where an embryo is split in the maturation before embryo transfer. It is optimally performed at the 6- to 8-cell stage, where it can be used as an expansion of IVF to increase the number of available embryos. If both embryos are successful, it gives rise to monozygotic (identical) twins.

ADVANTAGES

1. Better understanding of the **ageing process** as human cloning will throw more light on the chemistry of cell division.
2. Better cure for certain types of **cancer.**
3. Can understand the **cause behind non-regeneration of the once destroyed heart or brain cells.**

ETHICAL QUESTIONS INVOLVED

Because of recent technological advancements, the cloning of animals (and potentially humans) has been an issue. Many religious organizations oppose all forms of cloning, on the grounds that life begins at conception. From the standpoint of classical liberalism, concerns also exist regarding the protection of the identity of the individual and the right to protect one's genetic identity.

Critics have raised objections to the FDA's approval of cloned-animal products for human consumption, arguing that the FDA's research was inadequate, inappropriately limited, and of questionable scientific validity. Another concern is that the biotechnologies used on animals may someday be used on humans. Some people may be more open to the idea of cloning of animals because most western countries have passed legislation against cloning humans, yet only a few countries passed legislation against cloning animals.

CURRENT LAW

INDIA

The bioethics committee functioning under the department of Biotechnology has banned human cloning for reproductive purposes.

UNITED KINGDOM

Britain became the first country to legalize therapeutic cloning in 2001.

UNITED NATIONS

UNs General Assembly adopted a non-binding *United Nations Declaration on Human Cloning* calling for the ban of all forms of Human Cloning contrary to human dignity in March 2005.

AUSTRALIA

Therapeutic cloning is legal in some parts of Australia since December 2006.

UNITED STATES

There are currently no federal laws in the United States which ban cloning completely, and any such laws would raise difficult Constitutional questions similar to the issues raised by abortion. Thirteen American states (Arkansas, California, Connecticut, Iowa, Indiana, Massachusetts, Maryland, Michigan, North Dakota, New Jersey, Rhode

Island, South Dakota, Virginia) ban reproductive cloning and three states (Arizona, Maryland, Missouri) prohibit use of public funds for such activities.

TISSUECULTURE (CLONING IN PLANTS)

Tissue Culture is the technique of growing microorganisms or cells or tissues or organs to the desired genetic purity with properties such as high yield & disease resistance, on artificial medium in suitable container under controlled environmental conditions.

ADVANTAGES

- **Clonal propagation** in a mass scale, especially of ornamental & horticulture plants, which have a great export potential.
- Obtaining **disease free plant** material.
- Producing **biologically active compounds** for pharmaceutical industry.
- Can help in producing crops which can withstand high salinity, aridity & other inhospitable conditions.
- It has **vast potential in genetic engineering** in which foreign genetic materials are introduced to make tailor-made individuals.
- **Conservation of endangered plant species**& present by cryopreservation.

STEM CELLS

QUESTIONS ASKED IN THE PREVIOUS YEARS:

1. What are stem cells? Why have they been in the news recently? Discuss (2001/30M).

Stem cells are **undifferentiated, primitive cells** that have the potential to develop into many different cell types such as muscles, kidney, liver, blood and even nerve cells, in the body during early life and growth. In addition, in many tissues they serve as a sort of internal repair system, dividing essentially without limit to replenish other cells as long as the person or animal is still alive. When a stem cell divides, each new cell has the potential either to remain a stem cell or become another type of cell with a more specialized function, such as a muscle cell, a red blood cell, or a brain cell.

CHARACTERISTICS OF STEM CELLS DISTINGUISHING THEM FROM OTHER CELLS:

1. They are unspecialized cells capable of renewing themselves through cell division, sometimes after long periods of inactivity.
2. Under certain physiological or experimental conditions, they can be induced to become tissue- or organ-specific cells with special functions.

In some organs, such as the gut and bone marrow, stem cells regularly divide to repair and replace worn out or damaged tissues. In other organs, however, such as the pancreas and the heart, stem cells only divide under special conditions.

Given their unique regenerative abilities, stem cells offer new potentials for treating diseases such as diabetes, and heart disease. However, much work remains to be done in the laboratory to understand how to use these cells for **cell-based therapies** to treat disease, which is also referred to as **regenerative or reparative medicine.**

Research on **stem cells** continues to advance knowledge about how an organism develops from a single cell and how healthy cells replace damaged cells in adult organisms.

TYPES OF STEM CELLS:

1. **Embryonic Stem Cells** (Totipotent precursor stem cells) that can be differentiated in to most of the cell types.
2. **Non-embryonic/ somatic or adult stem cells**
   a. **Pluripotent precursor stem cells** that can be differentiated in many cell types E.g.: Umbilical cord stem cells
   b. **Oligopotent precursor stem cells** That can be differentiated into few other cell types E.g.: Bone marrow cells
3. **Induced Pluripotent precursor Stem Cells (iPSCs)**are the adult somatic cells that can be induced to show the properties of stem cells, by a process called de differentiation.

EMBRYONIC STEM CELLS

Embryonic stem cells are derived from embryos. Most embryonic stem cells are derived from embryos that develop from eggs that have been fertilized ***in vitro***—in an ***in vitro*** fertilization clinic—and then donated for research purposes with informed consent of the donors.

Human embryonic stem cells (hESCs) are generated by transferring cells from a preimplantation-stage embryo into a plastic laboratory culture dish that contains a nutrient broth known as **culture medium**. The cells divide and spread over the surface of the dish.

Embryonic stem cells that proliferate in cell culture for a prolonged period of time without differentiating, are **pluripotent**, and don't develop genetic abnormalities are referred to as an **embryonic stem cell line.**

NON EMBRYONIC STEM CELLS OR ADULT STEM CELLS

An adult stem cell or somatic stem cell is thought to be an undifferentiated cell, found among differentiated cells in a tissue or organ that can renew itself and can differentiate to yield some or all of the major specialized cell types of the tissue or organ. The primary roles of **adult stem cells** in a living organism are to maintain and repair the tissue in which they are found.

Adult stem cells have been identified in many organs and tissues, including brain, bone marrow, peripheral blood, blood vessels, skeletal muscle, skin, teeth, heart, gut, liver, ovarian epithelium, and testis. They are thought to reside in a specific area of each tissue (called a **"stem cell niche"**).

Adult hematopoietic or blood-forming, stem cells from bone marrow have been used in transplants for 40 years. If the differentiation of adult stem cells can be controlled in the laboratory, **these cells may become the basis of transplantation-based therapies.**

SOURCES OF STEM CELLS

Embryonic stem cells are harvested from the core of 5-7 days human embryos. Adult stem cells are derived from the bone marrow.

POTENTIAL USES OF STEM CELLS

Studies of human embryonic stem cells will yield information about the complex events that occur during human development. A primary goal of this work is to identify how undifferentiated stem cells become the differentiated cells that form the tissues and organs. Scientists know that turning genes on and off is central to this process. Some of the most serious medical conditions, such as cancer and birth defects, are due to abnormal cell division and differentiation. Human stem cells could be used to test new drugs. For example, new medications could be tested for safety on differentiated cells generated from human pluripotent cell lines. Other kinds of cell lines are already used in this way. Cancer cell lines, for example, are used to screen potential anti-tumor drugs. The availability of pluripotent stem cells would allow drug testing in a wider range of cell types. However, to screen drugs effectively, the conditions must be identical when comparing different drugs. Therefore, scientists will have to be able to precisely control the differentiation of stem cells into the specific cell type on which drugs will be tested.

Perhaps the most important potential application of human stem cells is the generation of cells and tissues that could be used for cell-based therapies. Today, donated organs and tissues are often used to replace ailing or destroyed tissue, but the need for transplantable tissues and organs far outweighs the available supply. Stem cells, directed to differentiate into specific cell types, offer the possibility of a renewable source of replacement cells and tissues to treat diseases including Alzheimer's diseases, spinal cord injury, stroke, burns, heart disease, diabetes, osteoarthritis, and rheumatoid arthritis.

REPRODUCTIVE TECHNOLOGIES

QUESTIONS ASKED IN THE PREVIOUS YEARS:

1. Discuss the elements of 'frozen semen technology'. What are 'embryo transfer', 'transgenic animals', 'DNA recombinant technique'?(2003/15M)

Reproductive technologies have undergone a rapid evolution from simple procedures like the first **insemination of fresh donor semen** to a point where we now have the **ability to collect epididymal sperm for microinjection into oocytes;** freeze, thaw, and transfer donor gametes and embryos; create pregnancies in menopausal women, and in the near future may be able to harvest and store eggs from ovarian biopsies.

THE CONCEPT OF CELL BANKS: Cell banks are the places where the cells can be stored in liquid nitrogen at -196^{0}C. At these conditions the cells can be preserved in healthy condition for up to few decades. Depending on what cells are being preserved, the cell banks can be either egg banks, sperm banks or the stem cell banks. Egg banks and sperm banks are very important for almost all types of artificial fertility techniques.

MAJOR REPRODUCTIVE TECHNOLOGIES

1. **IN VITRO FERTILIZATION (IVF):** In Vitro Fertilization involves collection of healthy ovum and sperms from healthy mother and father respectively and their fusion under appropriate conditions in vitro. If fertilization occurs, the resulting embryo is transferred in to the woman's uterus, where it will implant in the lining of the uterus and develop.

- **BASIC TECHNIQUE IN IVF**
    - First of all **ovaries are stimulated** by using fertility drugs to produce several mature eggs rather than a single egg.
    - Then **ultrasound probe** is inserted through vagina and **mature follicles are identified,**
    - Then a needle is guided through the vagina into the follicles.
    - The **eggs are removed from the follicles** through the needle by a suction device.
    - At last, in the laboratory, the sperms are separated from the seminal plasma, and the motile sperms are placed together with each retrieved egg in a separate dish containing IVF culture medium, where **fertilization occurs.**
    - The embryos are drawn into a tube and deposited in the uterine cavity.

2. **EMBRYO TRANSFER TECHNOLOGY.** Embryo transfer is a procedure by which fertilized egg or young embryo is transferred from donor mother to recipient mother or from test tube (IVF) to the recipient mother. The best stage for transfer is 2-4 cell stage. Embryo transfer technology is used for rapid multiplication of genetically superior genotype.

3. **CLONING.** Cloning is the **production of identical** animals, **plants or microorganisms from a single individual.** A clone means exact copy or copies of a single parent. Clones, owing to their identical genetic make up exhibit little, if any genetic variation. **Monozygotic identical twins are clones. "Dolly"**, the **sheep**, was a clone. Dolly was produced from a single cell from her mother. She had exactly the same genetic characteristics as her mother, the single parent.

4. **ARTIFICIAL WOMBS.** Artificial wombs technique could be used **to help premature or "sick" human babies to survive** and help foetuses in the final stages of multiple pregnancies when the womb becomes so cramped. In this technique a foetus of about 17 weeks is placed in a tank filled with liquid to stimulate amniotic fluid. The temperature is kept at constant. A machine pumps nutrients and oxygen into the baby's blood. This technique was successfully experienced **on goat foetus in Japan.**

5. **ARTIFICIAL INSEMINATION** - Artificial insemination is the **artificial introduction of semen into the reproductive tract of a female.** Semen collected from a male with desirable hereditary characters can be frozen and transported through long distances to fertilize females.

The method is used **for those females who wish to conceive when normal conception is not possible.**

6. **GAMETE INTRA-FALLOPIAN TRANSFER (GIFT)** - GIFT **begins with ovulation induction** as in IVF followed by egg retrieval, insemination and gamete transfer. Sperms and eggs are mixed and injected into the fallopian tubes. The fertilization takes place there as it does naturally.

7. **SURROGACY** - An embryo may be carried by the **egg donor (Surrogate)** or by **another woman (gestational carrier)**. In the latter case, the eggs are removed from the infertile woman, fertilized using IVF, and the resulting embryo is placed into the gestational carrier's uterus.

HUMAN GENOME PROJECT (HGP)

QUESTIONS ASKED IN THE PREVIOUS YEARS:

1. What is the human genome project? Discuss briefly its importance. (1999/20M)
2. Discuss Human Genome. (2000/10M)
3. Explain the objectives and current achievements of human genome project. (2007/15M)

Human Genome refers to the **entire genetic makeup of human beings.** HGP is an international effort to identify and locate all the genes and their variants, understand their functioning and write down the sequence of nucleotides that comprise the genes. It was started formally in 1990 originally as a 15-year project coordinated by the US **Department of Energy and National Institute of Health.**

OBJECTIVES

The primary objectives of the project were:

1. **To identify all** the approximately 30, 000 **genes in human DNA.**
2. To determine **the sequence** of the 3 billion **chemical base pairs** that makes up human DNA.
3. To store this **information in databases.**
4. To improve tools for **data analysis.**
5. To **address the ethical, legal and social issues** that may arise from the project.

BENEFITS OF HGP

The importance of the event stems from the fact that it holds the key to almost everything that defines a human being including the physical traits, habits and more importantly, proneness to certain diseases. This could enable doctors to find out whether an individual is genetically predisposed to develop certain diseases later in life and may be to recommend preventive measures or even corrective actions using newly developed drugs and treatments. The better understanding of genome might help in diagnosing genetic diseases at an early stage or even before birth.

PROBLEMS WITH HGP

At the same time **genomic** data **can be misused.** E.g. the patients taking the tests face significant risk of jeopardizing their employment or insurance status unless absolute confidentiality of such knowledge is made mandatory. And because genetic information is shared, these risks may extend beyond them to their family members as well.

PROJECT ENCODE (ENCYCLOPEDIA OF DNA ELEMENTS)

The ENCODE Project was planned as a follow-up to the Human Genome Project. The Human Genome Project sequenced the DNA that makes up the human genome whereas the ENCODE Project seeks to interpret this sequence. It was launched by launched by the US National Human Genome Research Institute (NHGRI) in September 2003.

The approximately 20,000 genes that provide instructions for making proteins account for only about 1 percent of the human genome. Researchers embarked on the ENCODE Project to figure out the purpose of the remaining 99 percent of the genome. Scientists discovered that more than 80 percent of this non-gene component of the genome, which was once considered "junk DNA," actually has a role in regulating the activity of particular genes (gene expression).

A goal of the ENCODE Project is to link variations in the expression of certain genes to the development of disease. The ENCODE Project has given researchers insight into how the human genome functions. As researchers learn more about the regulation of gene activity and how genes are expressed, the scientific community will be able to better understand how the entire genome can affect human health.

DNA FINGERPRINTING (DF)

QUESTIONS ASKED IN THE PREVIOUS YEARS:

1. Where is centre for Cellular and Molecular biology located? (1999/1M)
2. DNA fingerprinting and its utility (2009/10M)

The chemical structure of everyone's DNA is the same. The only difference between people or any animal is the order of the base pairs. Using these sequences, every person could be identified solely by the sequence of their base pairs. However, because there are so many millions of base pairs, the task would be very time-consuming.

DNA Fingerprinting (also called DNA typing, DNA testing or DNA profiling) is the technology of identifying individuals from certain repeating sequences in their DNA, that don't code for any protein, which are termed as **VNTRs (Variable** number **Tandem repeats) or Minisatellites.** For example, **ATTCG ATTCG ATTCG, in which sequence ATTCG is repeated thrice.** The technology was developed by British geneticist **'Alec Jeffreys'** (1984) at the University of Leicester in England.

TECHNIQUES

1. DNA sample typically called a 'reference sample' is obtained which can either be in the form of **skin, blood, hair saliva, tear etc.**
2. From these samples, DNA is first **isolated, extracted & purified.**
3. Cut in to segments of various lengths using **restriction enzymes.**

4. DNA fragments of various lengths are sorted according to size by a technique known as **gel electrophoresis.**
5. At the end, sorted double stranded DNA fragments are subjected to heat or chemically treated to break them up in to the single strands.

   The band pattern of Single Stranded DNA obtained is then blotted (transmitted) to a nylon or nitrocellulose membrane. This is known as **Southern Blotting**.
6. When the southern blot is treated with a single strand DNA 'Probe' tagged with a **radioactive isotope**, a unique DNA pattern with part of it containing radioactive isotope is left behind.
7. If a sheet of X-ray film is now placed in contact with the southern blot, only the areas where radioactive probe binds show up on the film. The resulting pattern of dark bands on the developed X-ray film is the DNA fingerprint.

USES

1. DNA Fingerprinting can be used to **identify & convict criminals** in cases of murder and rape.
2. It serves as a powerful tool for **settling paternity disputes & identifying dead persons.**
3. It is also used for the purpose of **detecting genetic disorder, pedigree analysis**& in identifying genetic stock.

In India, pioneering work in developing DNA probes for DNA fingerprinting has been done by **'Lalji Singh'** at Centre for Cell and Molecular Biology **(CCMB), Hyderabad.** Other centres exclusively for DNA fingerprinting are **Centre for DNA Fingerprinting & Diagnostics** (CDFD), Hyderabad and Central Forensic Science Laboratory (CFSL), Kolkata.

BIOSENSORS

QUESTIONS ASKED IN THE PREVIOUS YEARS:

1. What are biosensors? Describe their uses (1999/20M)

Biosensors are small devices that utilize biological reactions for detecting target analytes, which are chemical substrates being measured by the sensor. **Clark and Lyons** first demonstrated the modern concept of biosensors, in which an enzyme was integrated into an electrode to form a biosensor. The development of biosensors is concerned with the **production of diagnostic reagent-less analysis** probes, which can be used by non-specialist operators, either continuously online or discretely as a 'throw-away' device.

APPLICATIONS

- **Health care**: Biosensors can effectively be used to monitor the glucose levels in diabetic patients.
- **Military applications:** The requirements for rapid analysis can also be anticipated in the military applications. The sensors can recognize when a soldier

is bleeding and whether the cut is in a vein or artery, depending on the oxygen content in the blood.

- **Environmental monitoring:** The biosensors are used for monitoring harmful bacteria in drinking water, wastewater, and industrial effluents. Rapid and automated biosensors provide an early warning signal that prevents the real threat of releasing biohazards materials into the environment.
- **Drug discovery:** Biosensors can detect the interaction between a particular target and a possible drug without using markers or the detection of color changes or fluorescence.
- **Pathogen detection in food:** Biosensors that rapidly detect total microbial contamination are also essential tools for the food quality assurance and open doors to the market share of the food biosensors.

Biomarker

A **biomarker**, or **biological marker**, is a substance used as an indicator of a biological state. It is a characteristic that is objectively measured and evaluated as an indicator of normal biological processes, pathogenic processes, or pharmacologic responses to a therapeutic intervention. It is used in many scientific fields.

MEDICINE

In medicine, a biomarker can be a traceable substance that is introduced into an organism as a means to examine organ function or other aspects of health. For example, rubidium chloride is used as a radioactive isotope to evaluate perfusion of heart muscle. It can also be a substance whose detection indicates a particular disease state, for example, the presence of an antibody may indicate an infection. Biochemical biomarkers are often used in clinical trials, where they are derived from bodily fluids that are easily available to the early phase researchers. A useful way of finding genetic causes for diseases such as schizophrenia has been the use of a special kind of biomarker called an *endophenotype*.

CELL BIOLOGY

In cell biology, a biomarker is a molecule that allows for the detection and isolation of a particular cell type (for example, the protein Oct-4 is used as a biomarker to identify embryonic stem cells).In genetics, a biomarker is a DNA sequence that causes disease or is associated with susceptibility to disease. They can be used to create genetic maps of whatever organism is being studied.

GEOLOGY AND ASTROBIOLOGY

A biomarker can be any kind of molecule indicating the existence, past or present, of living organisms. In the fields of geology and astrobiology, biomarkers, versus geomarkers, are also known as biosignatures. The term biomarker is also used to describe biological involvement in the generation of petroleum.

EXPOSUREASSESSMENT

A biomarker can also be used to indicate exposure to various environmental substances in epidemiology and toxicology. In these cases, the biomarker may be the external substance itself (e.g. asbestos particles), or a variant of the external substance processed by the body (a metabolite).

BIOINFORMATICS

QUESTIONS ASKED IN THE PREVIOUS YEARS:

1. Define Bioinformatics. How does it work? What are the major branches and applications? (2009/15M)

Bioinformatics is the application of computer science and information technology to the field of biology and medicine. It deals with various fields such as algorithms, databases and information systems, web technologies, artificial intelligence and soft computing, information and computation theory, software engineering, data mining, image processing, modelling and simulation, signal processing, and statistics, for generating new knowledge of biology and medicine, and improving & discovering new models of computation.

APPLICATIONS OF BIOINFORMATICS

Protein structure prediction is an important application of bioinformatics. The amino acid sequence of a protein, the so-called primary structure, can be easily determined from the sequence on the gene that codes for it. In the vast majority of cases, this primary structure uniquely determines a structure in its native environment. (Of course, there are exceptions, such as the *bovine spongiform encephalopathy* – also known as *Mad Cow Disease*). Knowledge of this structure is vital in understanding the function of the protein.

Another important idea in bioinformatics is the notion of *homology*. In the genomic branch of bioinformatics, homology is used to predict the function of a gene: if the sequence of gene *A*, whose function is known, is homologous to the sequence of gene *B*, whose function is unknown, one could infer that B may share A's function. In the structural branch of bioinformatics, homology is used to determine which parts of a protein are important in structure formation and interaction with other proteins. In a technique called homology modelling, this information is used to predict the structure of a protein once the structure of a homologous protein is known. This currently remains the only way to predict protein structures reliably.

GLOSSARY

QUESTIONS ASKED IN THE PREVIOUS YEARS:

1. What are normal osmosis and reverse osmosis? Why has reverse osmosis become popular in India today (2006/15M)
2. Write about green fluorescence protein (GFP) and its application (2009/15M)
3. ACTN3 gene (2010/3M)
4. MRSA infection (2010/5M)
5. Omega 3 fatty acids in our food (2011/3M)

- **Gene** - Smallest hereditary unit found in DNA molecule. Genes give coded information/instructions to the cells on how to manufacture proteins that are necessary for the cell for its functioning, repair, defence, division and multiplication. The making of proteins by the cell from this code is called Gene expression.

- **Gene Cloning** - Isolation of gene and replication of a single copy of gene or DNA segment into on infinite number of copies, all identical, is known as gene cloning.
- **Genome** - It may be defined as the complete genetic information carried by an Individual or the range of genes found in a given species. In human beings this corresponds to twenty-three pairs of chromosomes.
- **Codon** - Triplet of bases that codes for one of the amino acids used for protein synthesis in a living cell.
- **Interferon** - It is a powerful anti-viral protein made by cells against viral infection. Now, interferons are produced outside the body with the help of genetic engineering.
- **Sweet Bugs** - It is a bacterium that turns coconut water into delicious confectionary and also produces vinegar from it. The name of the bacterium is Acetobactor Spoxylinum. The confectionaries are also called BIO-SWEETS.
- **Traitor DNA** - It is unstable DNA that may be present in Human Genome, which have the property of enlarging itself. It can result in diseases like Huntington's disease, fragile X-syndrome etc. It can be used by Gene Therapy.
- **Genetically Modified Organism** – An organism (Plant, bacteria, fungi or animals) that has been modified, or transformed, using modern techniques of genetic exchange is commonly referred to as a genetically-modified organism (GMO).
- **RNA Interference** – A novel strategy adopted to prevent infestation of nematode Meloidegyne incognitia in roots of tobacco plants by a process called RNA interference.
- **ELISA** – Enzyme Linked Immuno Sorbent Assay
- **ADA** – Adenosine Deaminase is an enzyme which is crucial for the immune system to function.
- **Biopiracy** – It is a term used to refer to the use of bio-resources by MNCs and other organizations without proper authorization from the countries and people concerned without compensatory payment.
- **Biomass:** Material produced by or remaining after the death of organisms (e.g., bacteria, plants, and animals).
- **Bioremediation:** The use of organisms, usually microorganisms, to break down pollutants in soil, air or groundwater. It can be classified as *in situ* or *ex situ*. ***In situ*** bioremediation involves treating the contaminated material at the site, while ***ex situ*** involves the removal of the contaminated material to be treated elsewhere. Some examples of bioremediation technologies arephytoremediation, bioleaching, landfarming, bioreactor, composting, bioaugmentation, rhizofiltration, and biostimulation.
- **Biosignature:** It is any substance -such as an element, isotope, or molecule - or phenomenon that provides scientific evidence of past or present life. Measurable attributes of life include its complex physical and chemical structures and also its utilization of free energy and the production of biomass and wastes. Due to its

unique characteristics, a biosignature can be interpreted as having been produced by living organisms, however, it is important that they not be considered definitive because there is no way of knowing in advance which ones are universal to life and which ones are unique to the peculiar circumstances of life on Earth.

- **Biomimetics:** It is the study of the structure and function of biological systems as models for the design and engineering of materials and machines.The term biomimetics is derived from the Greek word '*bios*' which means "life" and the suffix '*mimetic*' which means "having an aptitude for mimicry". A similar term, **'Bionics'** is defined as "the science of systems which have some function copied from nature, or which represent characteristics of natural systems or their analogues".
- **Biobots** is the future of regenerative medicine – a low cost, high resolution 3-D bioprinter that supports the use of photocurable materials and is accessible to millions of customers.
- **Bioprinting** can be defined as the use of computer-aided transfer processes for patterning and assembling living and non-living materials with a prescribed 2D or 3D organization in order to produce bio-engineered structures serving in regenerative medicine, pharmacokinetic and basic cell biology studies.
- **Nucleic acids** are biological molecules essential for life, and include DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). Together with proteins, nucleic acids make up the most important macromolecules; each is found in abundance in all living things, where they function in encoding, transmitting and expressing genetic information.
- **DNA** (Deoxyribonucleic acid): The chemical molecule that is the basic genetic material found in all cells. Each unit of DNA is made of nucleotides: adenine (A), guanine (G), thymine (T) and cytosine (C), as well as a sugar and a phosphate. DNA is inherited. DNA is a very long, thin molecule, it is packaged into units called chromosomes.
- **RNA or Ribonucleic acid**, is one of the three major macromolecules (along with DNA and proteins) that are essential for all known forms of life. Like DNA, RNA is made up of a long chain of components called nucleotides. Each nucleotide consists of a nucleobase, a ribose sugar, and a phosphate group. The sequence of nucleotides allows RNA to encode genetic information.
- **Translation** is the third stage of protein biosynthesis. In translation, messenger RNA (mRNA) produced by transcription is decoded by the ribosome to produce a specific amino acid chain, or polypeptide, that will later fold into an active protein.
- **Transcription** is the process of creating a complementary RNA copy of a sequence of DNA.
- **DNA replication** is a biological process that occurs in all living organisms and copies their DNA; it is the basis for biological inheritance. The process starts with one double-stranded DNA molecule and produces two identical copies of the molecule. Each strand of the original double-stranded DNA molecule serves as template for the production of the complementary strand, a process referred to as semi-conservative replication.

- **Reverse transcriptase**, also known as **RNA-dependent DNA polymerase**, is a DNA polymerase enzyme that transcribes single-stranded RNA into single-stranded DNA. It also is a **DNA-dependent DNA polymerase** which synthesizes a second strand of DNA complementary to the reverse-transcribed single-stranded cDNA after degrading the original mRNA with its RNaseH activity.
- **Intron:** An **Intron** is any nucleotide sequence within a gene that is removed by RNA splicing while the final mature RNA product of a gene is being generated. The term *intron* refers to both the DNA sequence within a gene, and the corresponding sequence in RNA transcripts. Sequences that are joined together in the final mature RNA after RNA splicing are exons. Introns are found in the genes of most organisms and many viruses, and can be located in a wide range of genes, including those that generate proteins, ribosomal RNA (rRNA), and transfer RNA (tRNA). When proteins are generated from intron-containing genes, RNA splicing takes place as part of the RNA processing pathway that follows transcription and precedes translation.
- **Exon:** An **Exon** is a nucleic acid sequence that is represented in the mature form of an RNA molecule either after portions of a precursor RNA (introns) have been removed by cis-splicing or when two or more precursor RNA molecules have been ligated by trans-splicing. The mature RNA molecule can be a mRNA or a functional form of a non-coding RNA such as rRNA or tRNA. Depending on the context, exon can refer to the sequence in the DNA or its RNA transcript.
- Splicing: In molecular biology and genetics, **splicing** is a modification of an RNA after transcription, in which introns are removed and exons are joined. This is needed for the typical eukaryotic mRNA before it can be used to produce a correct protein through translation.
- Pseudogenes: These are DNA sequences, related to known genes, that have lost their protein-coding ability or are otherwise no longer expressed in the cell. Pseudogenes arise from retrotransposition or genomic duplication of functional genes, and become "genomic fossils" that are nonfunctional due to mutations that prevent the transcription of the gene, such as within the gene promoter region, or fatally alter the translation of the gene, such as premature stop codons or frameshifts. Pseudogenes resulting from the retrotransposition of an RNA intermediate are known as *processed pseudogenes*; pseudogenes that arise from the genomic remains of duplicated genes or residues of inactivated genes are *nonprocessed pseudogenes*.
- **Telomeres:** These are regions of repetitive DNA at the end of a chromosome, which provide protection from chromosomal deterioration during DNA replication.
- **Recombinant DNA (rDNA)** - Breakage of DNA molecule at two desired places to isolate a specific DNA fragment and then inserting it in another DNA molecule at a desired position results in a new gene product which is called as recombinant DNA. The receiving organism is said to be 'transgenic'. rDNA technology is usually used synonymously with genetic engineering.
- **Terminator Seeds** - The genetically modified (GM) variety of crop seeds that germinate only once. i.e. these seeds can't be used for subsequent swing.

- **Noncoding DNA:** In genetics, **noncoding DNA** describes components of an organism's DNA sequences that do not encode for protein sequences. In many eukaryotes, a large percentage of an organism's total genome size is noncoding DNA. Much of this DNA has no known biological function and is sometimes referred to as "**junk DNA**". However, many types of noncoding DNA sequences do have known biological functions, including the transcriptional and translational regulation of protein-coding sequences.
- **Selfish DNA:** It refers to those sequences of DNA which, in their purest form, have two distinct properties: (1) the DNA sequence spreads by forming additional copies of itself within the genome; and (2) it makes no specific contribution to the reproductive success of its host organism.
- **Non-coding RNA (ncRNA):** It is a functional RNA molecule that is not translated into a protein. Non-coding RNA genes include highly abundant and functionally important RNAs such as transfer RNA (tRNA) and ribosomal RNA (rRNA), as well as RNAs such as snoRNAs, microRNAs, and the long ncRNAs.. The number of ncRNAs encoded within the human genome is unknown, however recent transcriptomic and bioinformatic studies suggest the existence of thousands of ncRNAs. It is also known as non-protein-coding RNA (npcRNA) or non-messenger RNA (nmRNA) or functional RNA (fRNA). The term **small RNA (sRNA)** is often used for short bacterial ncRNAs. The DNA sequence from which a non-coding RNA is transcribed is often called an RNA gene.
- **DNA microarray:** It is also known as *gene chip, DNA chip, or biochip*. It is a collection of microscopic DNA spots attached to a solid surface. Scientists use DNA microarrays to measure the expression levels of large numbers of genes simultaneously or to genotype multiple regions of a genome. Each DNA spot contains picomoles (10^{-12} moles) of a specific DNA sequence, known as *probes* (or *reporters*). These can be a short section of a gene or other DNA element that are used to hybridize a cDNA or cRNA sample (called *target*) under high-stringency conditions.
- **DNA sequencing:** It includes several methods and technologies that are used for determining the order of the nucleotide bases—adenine, guanine, cytosine, and thymine—in a molecule of DNA.Knowledge of DNA sequences has become indispensable for basic biological research and discovery. The rapid speed of sequencing attained with modern DNA sequencing technology has been instrumental in the sequencing of the human genome, in the Human Genome Project.
- **Enzymes:** A protein that accelerates the rate of chemical reactions. Enzymes are catalysts that promote reactions repeatedly, without being damaged by the reactions.
- **Gene Therapy:** Altering DNA within cells in a living organism to treat or cure a disease. It is one of the most promising areas of biotechnology research. New genetic therapies are being developed to treat diseases such as cystic fibrosis, AIDS and cancer.
- **Molecular Biology:** A branch of biology concerned with studying the chemical structures and processes of biological phenomena at the molecular level

- **Plant Breeding:** It is the technique involving crossing plants to produce varieties with particular characteristics (traits) which are carried in the genes of the plants and passed on to future generations.
- **Polymerase Chain Reaction (PCR)** is a scientific technique in molecular biology to amplify a single or a few copies of a piece of DNA across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence.
- **Gene mapping**, also called **genome mapping**, is the creation of a genetic map assigning DNA fragments to chromosomes.
- **Plasmid:** is a DNA molecule that is separate from, and can replicate independently of, the chromosomal DNA. They are double-stranded and, in many cases, circular. Plasmids usually occur naturally in bacteria, but are sometimes found in eukaryotic organisms.
- **Gene expression** is the process by which information from a gene is used in the synthesis of a functional gene product. These products are often proteins, but in non-protein coding genes such as ribosomal RNA (rRNA), transfer RNA (tRNA) or small nuclear RNA (snRNA) genes, the product is a functional RNA.
- **Biogenerics or Biosimilars** are terms used to describe officially-approved subsequent versions of innovator biopharmaceutical products made by a different sponsor following patent and exclusivity expiry on the innovator product. Biosimilars are also referred to as **subsequent entry biologics (SEBs)** in Canada.
- Proteome: The **proteome** is the entire set of proteins expressed by a genome, cell, tissue or organism. The word "proteome" is a blend of "**protein**" and "**genome**", and was coined by Marc Wilkins in 1994. **Proteomics**, the study of the proteome, has largely been practiced through the separation of proteins by two dimensional gel electrophoresis.
- **Materiomics:** It is defined as the holistic study of material systems. Materiomics examines links between physiochemical material properties and material characteristics and function. The focus of materiomics is system functionality and behaviour, rather than a piecewise collection of properties. While typically applied to complex biological systems and biomaterials, materiomics is equally applicable to non-biological systems. Materiomics includes the study of a broad range of materials, which includes metals, ceramics and polymers as well as biological materials and tissues and their interaction with synthetic materials. Materiomics finds applications in elucidating the biological role of materials in biology, for instance in the progression and diagnosis or the treatment of diseases.
- **Vegetative reproduction (vegetative propagation, vegetative multiplication, vegetative cloning)** is a form of asexual reproduction in plants. It is a process by which new individuals arise without production of seeds or spores. It can occur naturally or be induced by horticulturists.
- **Parthenogenesis:** It is a form of asexual reproduction where growth and development of embryos occur without fertilization. In plants, parthenogenesis means development of an embryo from an unfertilized egg cell, and is a component process of apomixis. The word *parthenogenesis* comes from the Greek *parthenos*, meaning "virgin", and *genesis*, meaning "birth". The term is sometimes used

inaccurately to describe reproduction modes in hermaphroditic species that can reproduce by themselves because they contain reproductive organs of both sexes in a single individual's body.

- **Pharmacogenomics:** is the study of how the genetic inheritance of an individual affects his/her body's response to drugs. The vision of pharmacogenomics is to be able to design and produce drugs that are adapted to each person's genetic makeup.
- **Osmosis:** It is the net movement of solvent molecules through a partially permeable membrane into a region of higher solute concentration, in order to equalize the solute concentrations on the two sides. It may also be used to describe a physical process in which any solvent moves, without input of energy, across a semi-permeable membrane (permeable to the solvent, but not the solute) separating two solutions of different concentrations. Although osmosis does not require input of energy, it does use kinetic energy and can be made to do work.
- Net movement of solvent is from the less concentrated (*hypotonic*) to the more concentrated (*hypertonic*) solution, which tends to reduce the difference in concentrations. This effect can be countered by increasing the pressure of the hypertonic solution, with respect to the hypotonic. The osmotic pressure is defined to be the pressure required to maintain an equilibrium, with no net movement of solvent.
- Osmosis is essential in biological systems, as biological membranes are semi-permeable. In general, these membranes are impermeable to large and polar molecules, such as ions, proteins, and polysaccharides, while being permeable to non-polar and/or hydrophobic molecules like lipids as well as to small molecules like oxygen, carbon dioxide, nitrogen, nitric oxide, etc. Permeability depends on solubility, charge, or chemistry, as well as solute size. Water molecules travel through the plasma membrane, tonoplast membrane (vacuole) or protoplast by diffusing across the phospholipid bilayer via aquaporins (small transmembrane proteins similar to those in facilitated diffusion and in creating ion channels). Osmosis provides the primary means by which water is transported into and out of cells. The turgor pressure of a cell is largely maintained by osmosis, across the cell membrane, between the cell interior and its relatively hypotonic environment.
- **Reverse osmosis:** Reverse osmosis is a separation process that uses pressure to force a solvent through a semi-permeable membrane that retains the solute on one side and allows the pure solvent to pass to the other side. More formally, it is the process of forcing a solvent from a region of high solute concentration through a membrane to a region of low solute concentration by applying a pressure in excess of the osmotic pressure.
- **Diffusion:** It refers to the process by which molecules intermingle as a result of their kinetic energy of random motion. Consider two containers of gas A and B separated by a partition. The molecules of both gases are in constant motion and make numerous collisions with the partition. If the partition is removed as in the lower illustration, the gases will mix because of the random velocities of their molecules. In time a uniform mixture of A and B molecules will be produced in the container. The tendency toward diffusion is very strong even at room temperature because of the high molecular velocities associated with the thermal energy of the particles.

- **Green Fluorescent Protein (GFP)** is a protein composed of 238 amino acid residues that exhibits bright green fluorescence when exposed to ultraviolet blue light. Although many other marine organisms have similar green fluorescent proteins, GFP traditionally refers to the protein first isolated from the jellyfish *Aequorea victoria*. The GFP from *A. victoria* has a major excitation peak at a wavelength of 395 nm and a minor one at 475 nm. In cell and molecular biology, the GFP gene is frequently used as a reporter of expression. In modified forms it has been used to make biosensors, and many animals have been created that express GFP as a proof-of-concept that a gene can be expressed throughout a given organism.

  Martin Chalfie, Osamu Shimomura, and Roger Y. Tsien were awarded the 2008 Nobel Prize in Chemistry on 10 October 2008 for their discovery and development of the green fluorescent protein.

- The **pGLO** plasmid is an engineered plasmid used in biotechnology as a vector for creating genetically modified organisms. The plasmid contains several reporter genes, most notably for the green fluorescent protein (GFP) and the ampicillin resistance gene. GFP was isolated from the jelly fish *Aequorea victoria*. Because it shares a bidirectional promoter with a gene for metabolizing arabinose, the GFP gene is expressed in the presence of arabinose, which makes the transgenic organism fluoresce under UV light. GFP can be induced in bacteria containing the pGLO plasmid by growing them on arabinose plates.

  pGLO is made up of three genes that are joined together using recombinant DNA technology. They are as follows:-Bla, which codes for the enzyme beta-lactamase giving the transformed bacteria resistance to the beta-lactam family of antibiotics (such as of the penicillin family)-araC, a promoter region that regulates the expression of GFP (specifically, the GFP gene will be expressed only in the presence of arabinose)-GFP, the green fluorescent protein

- **Yellow Fluorescent Protein (YFP)** is a genetic mutant of green fluorescent protein, derived from *Aequorea victoria*. Its excitation peak is 514nm and its emission peak is 527nm. Like green fluorescent protein (GFP), it is a useful tool in cell and molecular biology, usually explored using fluorescence microscopy.

- **Omega-3 fatty acids** (popularly referred to as ω−3 fatty acids or n-3 fatty acids) are fats commonly found in marine and plant oils. They are polyunsaturated fatty acids with a double bond (C=C) starting after the third carbon atom from the end of the carbon chain. The fatty acids have two ends—the acid (COOH) end and the methyl (CH3) end. The location of the first double bond is counted from the methyl end, which is also known as the omega (ω) end or the n end. N-3 fatty acids have many health benefits and are considered essential fatty acids, meaning that they cannot be synthesized by the human body but are vital for normal metabolism.

- An **unsaturated fat** is a fat or fatty acid in which there is at least one double bond within the fatty acid chain. A fat molecule is monounsaturated if it contains one double bond, and polyunsaturated if it contains more than one double bond. Where double bonds are formed, hydrogen atoms are eliminated. Thus, a saturated fat has no double bonds, has the maximum number of hydrogens bonded to the carbons, and therefore is "saturated" with hydrogen atoms.

- **Saturated fat** is fat that consists of triglycerides containing only saturated fatty acids. Saturated fatty acids have no double bonds between the individual carbon atoms of the fatty acid chain. That is, the chain of carbon atoms is fully "saturated" with hydrogen atoms.

- ***BRCA1*** and **BRCA1** are a human gene and its protein product, respectively. The official symbol (BRCA1, italic for the gene, non-italic for the protein) *BRCA1* is a human tumour suppressor gene (to be specific, a caretaker gene), found in all humans; its protein, also called by the synonym **breast cancer type 1 susceptibility protein**, is responsible for repairing DNA.

  BRCA1 and BRCA2 are normally expressed in the cells of breast and other tissue, where they help repair damaged DNA or destroy cells if DNA cannot be repaired. They are involved in the repair of chromosomal damage with an important role in the error-free repair of DNA double-strand breaks..

- Methicillin-resistant Staphylococcus aureus (MRSA) is a bacterium responsible for several difficult-to-treat infections in humans. It is also called multidrug-resistant *Staphylococcus aureus* and oxacillin-resistant Staphylococcus aureus (ORSA). MRSA is any strain of Staphylococcus aureus that has evolved resistance to beta-lactam antibiotics, which include the penicillins (methicillin, dicloxacillin, nafcillin, oxacillin, etc.) and the cephalosporins. The development of such resistance does not cause the organism to be more intrinsically virulent than strains of *Staphylococcus aureus* that have no antibiotic resistance, but resistance does make MRSA infection more difficult to treat with standard types of antibiotics and thus more dangerous.

  MRSA is especially troublesome in hospitals and nursing homes, where patients with open wounds, invasive devices, and weakened immune systems are at greater risk of infection than the general public.

- ACTN3: **Alpha-actinin-3**, also known as **alpha-actinin skeletal muscle isoform 3** or F-actin **cross-linking protein**, is a protein that in humans is encoded by the ACTN3 gene. Alpha-actinin is an actin-binding protein with multiple roles in different cell types. This gene expression is limited to skeletal muscle. It is localized to the Z-disc and analogous dense bodies, where it helps to anchor the myofibrillar actin filaments.

- **Cisgenesis**, sometimes also called **Intragenesis**, is a product designation for a category of genetically engineered plants. Cisgenic plants contain genes that have been isolated either directly from the host species or from sexually compatible species. The new genes are introduced using recombinant DNA methods and gene transfer.

Note: Glossary is only for reference

CHAPTER – 6

INFORMATION TECHNOLOGY

Information technology (IT) is the use of any computers, storage, networking and other physical devices, infrastructure and processes to create, process, store, secure and exchange all forms of electronic data.

The Indian Information Technology (IT) - Information Technology Enabled Services (ITES) sector has registered tremendous growth over the past decade, achieving iconic status all over the world and a reputation for reliable and cost-effective delivery of IT services. India is the world's largest sourcing destination for the information technology (IT) industry, accounting for approximately 67 per cent of the US$ 124-130 billion market. The industry employs about 10 million workforce. The industry has led the economic transformation of the country and altered the perception of India in the global economy. The IT industry has also created significant demand in the Indian education sector, especially for engineering and computer science. The Indian IT and ITeS industry is divided into four major segments – IT services, Business Process Management (BPM), software products and engineering services, and hardware.

India's technology and BPM(Business Process Management) sector (including hardware) is likely to generate revenues of US$ 160 billion during FY16 compared to US$ 146.5 billion in FY15. The contribution of the IT sector to India's GDP rose to approximately 9.5 per cent in FY15 from 1.2 per cent in FY98.

DEPARTMENT OF ELECTRONICS & INFORMATION TECHNOLOGY (DEITY)

Department of Electronics and Information Technology (DeitY) in the Ministry of Communications and Information Technology is responsible for formulation, implementation and review of national policies in the field of Information Technology, Electronics and Internet.

The Mission is to promote e-Governance for empowering citizens, promoting the inclusive and sustainable growth of the Electronics and IT & ITeS industries.

The Vision of the Department coincides with the overarching vision outlined under the Digital India programme of making digital infrastructure as a utility to every citizen, Governance and Services on demand and Digital Empowerment of citizens.

The Department aims to promote electronics hardware manufacturing and IT-ITeS industry and provide e-infrastructure for delivery of e-services. It promotes the use of ICT for more inclusive growth. It also promotes Information Technology education and Information Technology-based education.

NATIONAL POLICY ON INFORMATION TECHNOLOGY 2012

The Policy aims to leverage Information & Communication Technology (ICT) to address the country's economic and developmental challenges. The policy is rooted in the conviction that ICT has the power to transform the lives of people. ICT and Electronics are contributing significantly to the Indian economy, society and governance. IT is a key driver of the knowledge based global economy. The right policies and investment in infrastructure can strengthen and enhance India's position as a global IT power-house. Use of IT can transform our economy, enhance equity and lead to improvement in development indices. The Policy envisages the growth of the IT market to USD 300 Billion and creation of additional 10 million employments by 2020. Thrust areas of the policy:

1. To increase revenues of IT and ITES (Information Technology Enabled Services) Industry from 100 Billion USD to 300 Billion USD by 2020 and expand exports from 69 Billion USD to 200 Billion USD by 2020.
2. To gain significant global market-share in emerging technologies and Services.
3. To promote innovation and R&D in cutting edge technologies and development of applications and solutions in areas like localization, location based services, mobile value added services, Cloud Computing, Social Media and Utility models.
4. To encourage adoption of ICTs in key economic and strategic sectors to improve their competitiveness and productivity.
5. To provide fiscal benefits to SMEs and Startups for adoption of IT in value creation
6. To create a pool of 10 million additional skilled manpower in ICT.
7. To make at least one individual in every household e-literate.
8. To provide for mandatory delivery of and affordable access to all public services in electronic mode.
9. To enhance transparency, accountability, efficiency, reliability and decentralization in Government and in particular, in delivery of public services.
10. To leverage ICT for key Social Sector initiatives like Education, Health, Rural Development and Financial Services to promote equity and quality.
11. To make India the global hub for development of language technologies, to encourage and facilitate development of content accessible in all Indian languages and thereby help bridge the digital divide.
12. To enable access of content and ICT applications by differently-abled people to foster inclusive development.
13. To leverage ICT for expanding the workforce and enabling life-long learning.
14. To strengthen the Regulatory and Security Framework for ensuring a Secure and legally compliant Cyberspace ecosystem.
15. To adopt Open standards and promote open source and open technologies

The policy attempts to optimally leverage India's global edge in ICT to advance national competitiveness in other sectors, particularly those of strategic and economic importance. The Policy will promote an inclusive and equitable society. The Policy is oriented towards use of ICT to consciously promote decentralization and empowerment of citizens.

NATIONAL DATA SHARING AND ACCESSIBILITY POLICY – 2012

The NDSAP policy is designed to promote data sharing and enable access to Government of India owned data for national planning and development. The National Data Sharing and Accessibility Policy will apply to all data and information created, generated, collected and achieved using public funds provided by Government of India directly or through authorised agencies by various Ministries/ Departments/ Organisations/ Agencies and Autonomous bodies. The objective of the policy is to facilitate access to Government of India owned shareable data and information in both human readable and machine readable forms through a network all over the country in a proactive and periodically updatable manner, within the framework of various related policies, Acts and Rules of the Government, therefore, permitting a wider accessibility and use of public data and information.

NATIONAL CYBER SECURITY POLICY 2013

It is a policy framework by Department of Electronics and Information Technology (DeitY), which aims at protecting the public and private infrastructure from cyber attacks. Due to the dynamic nature of cyberspace, there was a need for a National Cyber Security Policy, with an integrated vision and a set of sustained & coordinated strategies for securing the cyber space. It serves as an umbrella framework for defining and guiding the actions related to security of cyberspace. It also enables the individual sectors and organizations in designing appropriate cyber security policies to suit their needs. The policy provides an overview of what it takes to effectively protect information, information systems & networks and also gives an insight into the Government's approach and strategy for protection of cyber space in the country. This policy, therefore, aims to create a cyber security framework, which leads to specific actions and programmes to enhance the security posture of country's cyber space.

The vision of the policy is to build a secure and resilient cyberspace for citizens, businesses and government. It aims to protect information and information infrastructure in cyberspace, build capabilities to prevent and respond to cyber threats, reduce vulnerabilities and minimize damage from cyber incidents through a combination of institutional structures, people, processes, technology and cooperation.

Note: For details on Cyber Security Policy, refer to the Cyber Security chapter in the Internal Security material.

C-DAC — HIGH TECH ROAD TO DEVELOPMENT

ORIGIN AND DEVELOPMENT

The Centre for Development of Advanced Computing (C-DAC) was established in March 1988 as a scientific society of the Department of electronics & Information Technology (Deity). It is primarily a research and development institution involved in the design, development and deployment of advanced IT-based solutions. The two thrust areas of its first decade were **supercomputing** and **Indian Language Computing**. Over the years C- DAC has diversified its activities to address the requirements in various areas — financial and capital market simulation and modelling, networks and Internet Software, health care, e-governance, and artificial intelligence.

NEW C-DAC: C-DAC MK-II

In February 2003, the government announced the merger of the electronics Research and Development Centre of India (ER&DCI), the National Centre for Software Technology (NCST), the centre for Electronic Design and Technology India (CEDTI) with

C-DAC. The restructured C-DAC was expected to offer economies of scale and avoid duplication of work. As an effect, the enlarged C-DAC has become a major R&D player, with an asset base of around Rs.220 crore. The inevitable overlap in responsibilities has been largely adjusted after merger. The "C-DAC MK-II" is ready to address more challenging tasks warranted by its new human and infrastructural resources.

C-DAC — ITS VARIOUS MISSIONS

The C-DAC was started to fulfil need of indigenous supercomputing technology after IISc's (Indian Institute of Science) abortive attempt to purchase one of the leading American Supercomputer, the Cray, purely for academic research. The earlier Supercomputing projects were for in-house research and rarely given to captive departments or institutions. It was the C-DAC that worked towards techno-commercial success and found dozens of buyers in India and abroad for its **supercomputer-PARAM**, Sanskrit for supreme.

FIRST MISSION

It was aimed at creating a 1-gigaflop machine — that is billion mathematical calculations per second. The first Param 8000 machine was enhanced to Param and finally C-DAC upgraded Param 900 to 5 Gflops.

SECOND MISSION

It was launched in 1993 for period five years aiming for 100 Gflop machine, the Param-10000. Its engineers designed and built their own communication co-processor and also created own communication and inter-connecting hardware named ParamNet.

C-DAC established National Supercomputing Facility in Pune, with Param 10000 and its variant Param Ananth and invited researchers from dozens of scientific institutions. This move paid rich dividend, with its applications in seismic data processing, structural Mechanics, Molecular Modelling, Weather Forecasting and for emerging science of genetic mapping.

THIRD MISSION

It was launched in 1999 with short time span of three and half years. It was aimed at developing a teraflop machine — (Trillion floating point operations a second). C-DAC created its teraflop platform, the Param Padma. The Terascale Supercomputing facility within C-DAC knowledge Park in Bangalore was dedicated to Nation in April 2003. It took India for first time into the ranking of world's Top 500 supercomputers. It was ranked 171st. The next major step is faster computers but linked to a grid. The new area of Grid Computing is being explored in Prototype Grid Computing initiative (GARUDA).

C-DAC SCOPE WIDENED

It is true that C-DAC was a national initiative in supercomputing and was known for its pioneering role in Indian language computing. But over the years, the core competencies of C-DAC have widened in tune with progress in technology and national needs Its R&D activities include:

i. Applied Artificial Intelligence (AAI) and Speech Processing.

ii. Power Electronics.

iii. Embedded Systems and VLS1 Design

iv. Cyber Security

v. Broadband and Wireless and Internet Technologies

vi. Geomatics, Health Informatics

vii. Software technologies, Linux, Multimedia, Graphics, Database Technologies

viii. E-Governance, ICT for digital divide

ix. E-learning

BROADBAND

The concept of broadband, as popularly marketed, ensures high-speed connectivity between the service providers and the access users, delivering voice, data and video with high degree of interactivity. The two major essentials of broadband are multi-service component and its high speed. In short, broadband is a 'convergence' technology combining telecommunication, entertainment and web-based activities into a cohesive integrated whole.

SIGNIFICANCE OF BROADBAND TECHNOLOGY

The broadband technology has a potential to yield manifold social and economic benefits. It can act as tool of development by enabling wide-spread access and adopting at threshold pricing. There is no doubt that if efficiently delivered broadband will be the luring service available at the hands of consumer and synergy thus generated will have an enormous impact on economic development of the country in the following ways:

- Increase in overall Employment Opportunities
- Growth in national output level
- Increase in productivity levels of existing workforce
- Transformation of Indian Economy towards service sector based economy
- Amplify the business network to create new markets
- Affordable access will result in social saving reducing the digital divide

APPLICATIONS OF BROADBAND

The key sectors which will be benefited are:

1. Entertainment on Demand (EOD)

The EOD will be a killer application for broadband with multi-service mix through a single network. The key applications of EOD include Video on Demand, music downloads, on-line gaming and video chat.

2. Education

e-Education: Education through electronic media is widely termed as e-education. This incorporation of digital environment in dissemination of academic input transforms traditional system to more interactive mode that delivers superior learning at much less cost.

On-line Distance Education: The best way to address the problem of illiteracy in remote areas is to provide on-line distance education through a high-speed and good quality of service. It seems attractive proposition, but real challenge to create locally relevant educational content.

Virtual Library: Another feature of education over broadband is creating a virtual library that is totally real time, irrespective of location and logistics.

3. Health

Telemedicine: This technology used information and communication networks to assist and deliver clinical services in rural and remote areas, where geographical distance is barrier between health care provider and patient.

e-Health: In recent years, the new broadband aided tele-medicine expanded its scope by including non-clinical medical services like research and administration along with delivery of clinical services. All this could be made possible with the help of broadband enabled network computing, video conferencing, specialized application software, database management systems.

ADVANTAGES OF E-HEALTH

1. The high quality diagnosis of complex ailments through an easy access to visual information necessary for clinical decision support system.
2. High communication link established make it possible local general practitioner to perform a complex medical surgery under guidance of specialist.
3. It will enable health professionals to hold on-line discussions, knowledge sharing and update to latest development.

4. Governance

e-Governance: It refers to use IT, especially web-based technologies, internet communication and inter-connected application enhancing easy access to and efficient delivery of government services to citizens, business and employees.

HURDLES IN GROWTH OF BROADBAND IN INDIA

1. Lack of awareness and maturity levels of Indian customer
2. Lack of appropriate local content.
3. Expensive Service: Broadband Subscription rates are higher because of higher infrastructure costs.
4. Low quality of Cable TV infrastructure and lack of organisation.

GRID COMPUTING

Grid Computing is an emerging computing model that provides the ability to perform higher 'throughput computing' by taking advantage of many networked computers. It creates a model of virtual computer architecture that is able to distribute a process execution across a parallel infrastructure using resources of many separate computers connected by a network (usually the internet) to solve large-scale computational problems. Grids provide the ability to perform computations on large data sets, by breaking them down into many smaller ones, or provide the ability to perform many more computations at once than would be possible on a single computer, by modelling a parallel division of labour between processes.

COMMON FEATURES OF GRID COMPUTING

1. It offers a model for solving massive computational problems by making use of the unused resources (CPU cycles or disc storage) of large numbers of disparate, often desktop computers treated as a virtual cluster embedded in a distribution telecommunication infrastructure.
2. It is ability to support computation across administrative domains set it apart from traditional computer clusters.
3. It has the design goal of solving problems too big for any single super-computer, whilst retaining the flexibility to work on multiple smaller problems. Thus it provides multi-user environment.

APPLICATIONS

Today corporates; small and large, have realized, that to be ahead of the competition, they need to improve enterprise infrastructure both computational and storage and improve business processes.

Grid computing offers a way to solve grand challenge problems like protein folding, financial modelling, earthquake simulation, climate modelling by optimizing use of information technology resources in organisation.

SOME EXAMPLES OF APPLICATIONS

(i) **Meteorology or Climate Modelling:** It offers way to solve massive computational problems, by means of combining unutilized power in thousands of personal computers, world-wide.

(ii) **Educational Institutes:** It is cheaper option of a cluster of standard computers, which can achieve teraflop performance by clever distribution of the task at hand, as they cannot afford the cost of supercomputer.

(iii) **Government Agencies:** It can be used to combine geographically spread high performance computing resources to tackle national tasks like electoral rolls or tax data bases.

CURRENT DEVELOPMENT IN GRID COMPUTING

The various industry groups are making concerted efforts as grid computing is not within the power of any one player to deliver, but an ecosystem where low cost and high volume processors, combine with 'blade server' technology, and storage options like storage area networks, with connectivity technology like Ethernet or Fibre Channel, all driven by a cost-effective and enterprise ready operating system.

GARUDA

Grid computing has been identified by C-DAC as next thrust area and government approved prototype Grid Computing Initiative (GARUDA) for implementation. It provides an underlying network fabric at 100 mbps at 17 locations to enable remote access to Param-Padma and Param-10000 Computers and other systems.

WORLD COMMUNITY GRID (WCG)

It is a new initiative that aims to build the world's largest network of computers — which it calls the worlds' largest public computing grid, to do research on areas such as medicine and environment. The WCG is supported by IBM, which has donated the hardware, software and technical services, which has developed the grid software platform. One can join WCG by downloading a software application from the Internet. When computer is idling, this software programme will use its power to work on grid's project. When it is in normal use, the software will stop working for the grid. The user need not provide any personal information to WCG after down loading software.

CELLULAR PHONE STANDARDS:

CDMA and GSM are the names of competing cellular phone standards.

GSM

Global system for mobile communications (GSM), an international standard, is a digital system using **TDMA** (Time Division Multiple Access) technology. Using TDMA, a **narrow band** that is 30 kHz wide and 6.7 milliseconds long is split time-wise into three time slots. Each conversation gets the radio for one-third of the time. This is possible because voice data that has been converted to digital information is compressed so that it takes up significantly less transmission space. Therefore, TDMA has three times the capacity of an analog system using the same number of channels.

GSM systems provide a number of useful features:

- Uses **encryption** to make phone calls more secure
- Data networking
- Short Message Service (SMS) for text messages and paging
- Call forwarding
- Caller ID
- Call waiting
- Multi-party conferencing

CDMA

Code-division multiple access (CDMA) refers to any of several protocols used in so-called second-generation (2G) and third-generation (3G) wireless communications. As the term implies, CDMA is a form of multiplexing, which allows numerous signals to occupy a single transmission channel, optimizing the use of available bandwidth. Audio input is first digitized into binary elements. The frequency of the transmitted signal is then made to vary according to a defined pattern (code), so it can be intercepted only by a receiver whose frequency response is programmed with the same code, so it follows exactly along with the transmitter frequency. There are trillions of possible frequency-sequencing codes, which enhance privacy and makes cloning difficult. CDMA is compatible with other cellular technologies; this allows for nationwide roaming.

CDMA VERSUS GSM

CDMA and GSM are the names of competing cellular phone standards. The two biggest differences between these standards are international compatibility, and how the networks handle activating phones. Outside the U.S. and Canada, most GSM phones will still work, while almost all CDMA phones simply can't be used overseas. The only ones that can are those that also have a GSM radio.

CDMA phones are activated remotely, by the carrier, using the phone's serial number, known as the ESN. Since each carrier has a database of all the ESNs that are approved for its network, this lets most CDMA carriers refuse to activate phones not originally intended for their network.

GSM phones are activated differently. Each account is associated with what's called a SIM card, or Subscriber Identity Module. This card carries an encrypted version of all the information needed to identify your wireless account to the network. Not only can you use a wider variety of phones with your service, it also allows you to take any GSM hardware and make it "your phone" instantly, including the ability to carry your contacts right on the SIM card. GSM's strength is in its flexibility. That's not to say CDMA providers don't have advantages. In the U.S., Sprint and Verizon on CDMA were well ahead of AT&T and T-Mobile on deploying high-speed Internet

GENERAL PACKET RADIO SERVICE (GPRS)

General packet radio service (GPRS) is a packet oriented mobile data service on the 2G and 3G cellular communication system's global system for mobile communications (GSM). GPRS usage is typically charged based on volume of data. This contrasts with circuit switching data, which is typically billed per minute of connection time, regardless of whether or not the user transfers data during that period. GPRS is a best-effort service, implying variable throughput and latency that depend on the number of other users sharing the service concurrently, as opposed to circuit switching, where a certain quality of service (QoS) is guaranteed during the connection.

MOBILE PHONE GENERATIONS

MOBILE RADIO TELEPHONE (OR 0G)

Mobile radio telephone systems preceded modern cellular mobile telephony technology. Since they were the predecessors of the first generation of cellular telephones, these systems are sometimes retroactively referred to as **pre cellular** (or sometimes zero generation) systems. These mobile telephones were usually mounted in cars or trucks, though briefcase models were also made. Motorola in conjunction with the Bell System operated the first commercial mobile telephone service, Mobile Telephone System (MTS) in the US in 1946, as a service of the wireline telephone company.

1G

1G refers to the first-generation of wireless telephone technology. These are the analog telecommunications standards that were introduced in the 1980s and continued until being replaced by 2Gdigital telecommunications. The main difference between two succeeding mobile telephone systems, 1G and 2G, is that the radio signals that 1G networks use are analog, while 2G networks are digital. But both systems use digital signalling to connect the radio towers (which listen to the handsets) to the rest of the telephone system.

2G

2G is short for second-generation wireless telephone technology. 2G cellular telecom networks were commercially launched on the GSM (Global System for Mobile Communication) standard in Finland. Three primary benefits of 2G networks over their predecessors were that phone conversations were digitally encrypted; 2G systems were significantly more efficient on the spectrum allowing for far greater mobile phone penetration levels; and 2G introduced data services for mobile, starting with SMS text messages. 2G technologies can be divided into TDMA (Time Division Multiple Access)-based and CDMA (Code Division Multiple Access)-based standards depending on the type of multiplexing used.

2.5G (GPRS)

2.5G is a stepping stone between 2G and 3G cellular wireless technologies. 2.5G (second and a half generation) is used to describe 2G-systems that have implemented a packet-switched domain in addition to the circuit-switched domain. It does not necessarily provide faster services because bundling of timeslots is used for circuit-switched data services (HSCSD) as well. 2.5G provides some of the benefits of 3G (e.g. it is packet-switched) and can use some of the existing 2G infrastructure in GSM and CDMA networks. The commonly known 2.5G technique is GPRS (General Packet Radio Service). GPRS can be used for services such as Wireless Application Protocol (WAP) access, Multimedia Messaging Service (MMS), and for Internet communication services such as email and World Wide Web access. GPRS data transfer is typically charged per megabyte of traffic transferred, while data communication via traditional circuit switching is billed per minute of connection time, independent of whether the user actually is utilizing the capacity or is in an idle state.

2.75G (EDGE)

A 2G mobile phone is a circuit switched digital mobile phone. A 3G mobile is a digital phone with rapid data according to one of the standards being a member of the IMT-2000 family of standards. After those terms were defined, slow packet switched data was added to 2G standards and called 2.5G. 2.75G is the term which has been decided on for systems which don't meet the 3G requirements but are marketed as if they do (e.g. CDMA-2000 without multi-carrier) or which do meet the requirements but aren't strongly marketed as such. (e.g. EDGE systems).Enhanced Data rates for GSM Evolution (EDGE), Enhanced GPRS (EGPRS), or IMT Single Carrier (IMT-SC) is a backward-compatible digital mobile phone technology that allows improved data transmission rates, as an extension on top of standard GSM.

3G

3G or 3rd generation mobile telecommunications is a generation of standards for mobile phones and mobile telecommunication services fulfilling the International Mobile Telecommunications-2000 (IMT-2000) specifications given by the International Telecommunication Union (ITU). Application services include wide-area wireless voice telephone, mobile Internet access, video calls and mobile TV, all in a mobile environment. 3G was relatively slow to be adopted globally. In some instances, 3G networks do not use the same radio frequencies as 2G so mobile operators must build entirely new networks and license entirely new frequencies, especially so to achieve high data transmission rates.

The bandwidth and location information available to 3G devices gives rise to applications not previously available to mobile phone users. Some of the applications are:

- Mobile TV– a provider redirects a TV channel directly to the subscriber's phone where it can be watched.
- Video on demand – a provider sends a movie to the subscriber's phone.
- Videoconferencing – subscribers' can see as well as talk to each other.
- Telemedicine – a medical provider monitors or provides advice to the potentially isolated subscriber.
- Location-based services – a provider sends localized weather or traffic conditions to the phone, or the phone allows the subscriber to find nearby businesses or friends.

(Discussed in detail in other part of the chapter)

3.5G

High-Speed Downlink Packet Access or HSDPA is a mobile telephony protocol. Also called 3.5G, HSDPA is a packet-based data service in W-CDMA downlink with data transmission up to 8-10 Mbit/s (and 20 Mbit/s for MIMO systems) over a 5MHz bandwidth in WCDMA downlink. HSDPA implementations includes Adaptive Modulation and Coding (AMC), Multiple-Input Multiple-Output (MIMO), Hybrid Automatic Request (HARQ), fast cell search, and advanced receiver design.

4G

4G is the fourth generation of cell phone mobile communications standards. A 4G system provides mobile ultra-broadband Internet access, for example to laptops with USB wireless modems, to smartphones, and to other mobile devices. Conceivable applications include amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing and 3D television.

In March 2008, the International Telecommunications Union-Radio communications sector (ITU-R) specified a set of requirements for 4G standards, named the International Mobile Telecommunications Advanced (IMT-Advanced) specification, setting peak speed requirements for 4G service at 100 megabits per second (Mbit/s) for high mobility communication (such as from trains and cars) and 1 gigabit per second (Gbit/s) for low mobility communication (such as pedestrians and stationary users).

As opposed to earlier generations, a 4G system does not support traditional circuit-switched telephony service, but all-Internet Protocol (IP) based communication such as IP telephony. Unlike 3G, which is based on two parallel infrastructures consisting of circuit switched and packet switched network nodes respectively, 4G will be based on packet switching *only*. This will require low-latency data transmission.

Long Term Evolution (LTE) is the latest wireless mobile broadband technology that will power future 4G, networks designed primarily for data transmission at unprecedented speeds. It uses spectrum to carry data traffic. Since LTE uses wider chunks of spectrum, data speeds on LTE based 4G networks are nearly four times faster than on 3G. LTE is also a scalable bandwidth technology that works alongside 2G and 3G. So a 3G operator can easily upgrade his network to LTE.

SATELLITE PHONE

A satellite telephone, satellite phone, or satphone is a type of mobile phone that connects to orbiting satellites instead of terrestrial cell sites. They provide similar functionality to terrestrial mobile telephones; voice, short messaging service and low-bandwidth internet access are supported through most systems. Depending on the architecture of a particular system, coverage may include the entire Earth, or only specific regions.

VIDEOCONFERENCING

Videoconferencing is the conduct of a videoconference (also known as videoteleconference) by a set of telecommunication technologies which allow two or more locations to communicate by simultaneous two-way video and audio transmissions. Videoconferencing differs from videophone calls in that it's designed to serve a conference or multiple locations rather than individuals.

Videoconferencing provides students with the opportunity to learn by participating in two-way communication forums. It is a highly useful technology for real-time telemedicine and telenursing applications, such as diagnosis, consulting, transmission of medical images, etc. Videoconferencing can enable individuals in distant locations to participate in meetings on short notice, with time and money savings. Press videoconferencing permits international press conferences via videoconferencing over the Internet. Journalists can participate on an international press conference from any location, without leaving their offices or countries. They need only be seated by a computer connected to the Internet in order to ask their questions to the speaker.

LOCATION-BASED SERVICES (LBS)

Location-based services are a general class of computer program-level services used to include specific controls for location and time data as control features in computer programs. As such (LBS) is an information and has a number of uses in Social Networking today as an entertainment service, which is accessible with mobile devices through the mobile network and which uses information on the geographical position of the mobile device. LBS are used in a variety of contexts, such as health, indoor object search, entertainment, work, personal life, etc. LBS include services to identify a location of a person or object, such as discovering the nearest banking cash machine or the whereabouts of a friend or employee. LBS include parcel tracking and vehicle tracking services. LBS can include mobile commerce when taking the form of coupons or advertising directed at customers based on their current location. They include personalized weather services and even location-based games. They are an example of telecommunication convergence.

VIDEO ON DEMAND

Video on Demand (VOD) or Audio and Video on Demand (AVOD) are systems which allow users to select and watch/listen to video or audio content on demand. IPTV technology is often used to bring video on demand to televisions and personal computers. Television VOD systems either stream content through a set-top box, a computer or other device, allowing viewing in real time, or download it to a device such as a computer, digital video recorder (also called a personal video recorder) or portable media player for viewing at any time. Internet television, using the Internet, is an increasingly popular form of video on demand. Tata Sky DTH services launched VOD services in India for TATA Sky+ HD subscribers commencing from 5 December 2011.

HIGH DEFINITION TELEVISION (HDTV)

There are three key differences between HDTV and standard definition TV

- an increase in picture resolution
- 16:9 widescreen as standard, and
- the ability to support multi-channel audio such as Dolby Digital.

The most important aspect of HDTV and the one which gives it its name is the increased resolution. Standard definition TV systems are characterized by **interlaced scanning**, that is, each frame is split into two fields, one field is the odd-numbered lines and the other is the even lines. Each frame is displayed alternately and our brain puts them together to create a complete image of each frame. This has an adverse affect on picture quality.

HDTV is broadcast in one of two formats; 720p and 1080i. The numbers refer to the number of lines of vertical resolution and the letters refer to whether the signal is progressive scan, 'p', or interlaced, 'i'. **Progressive scan** means that each frame is shown in its entirety, rather than being split into fields. Both systems are significantly better quality than standard definition TV broadcasts.

HDTV uses 16:9 widescreen as is its aspect ratio (screen width : screen height) so widescreen pictures are transmitted properly and not letterboxed or panned and scanned. HDTV is provided with digital image and sound system which is sharper than the ordinary TV. To receive an HDTV broadcast one needs a TV with a built-in HDTV tuner or a HDTV receiver which can pick-up off the air HDTV channels. One also needs to live in area where HDTV channels are broadcast or distributed by cable or satellite.

DTH (Direct to Home) BROADCASTING TECHNOLOGY

INTRODUCTION

In recent years, DTH has become the buzzword in the satellite broadcasting industry because of immense opportunities it offers to broadcasters and viewers alike. Hitherto, broadcasting in India has been through terrestrial, cable and satellite (C-band) modes. The growing demand from viewers for select information entertainment and programmes as well as the mounting pressure to conserve rapidly dwindling frequency spectrum have forced broadcasters to look for an economical and technologically viable medium.

DTH: HOW IT WORKS

DTH facilitates transmission of several digital channels through a single powerful Ku-band transponder on satellite that is in range 11 GHz to 14 GHz frequencies satellite. It involves two-stage process. First one involves uplinking, where broadcaster transmits audio and video programmes in the form of signals in a digital format to designated transponder fitted inside satellite. The transponder amplifies and changes that signal to a different format. The second, stage, called downlinking where signal sent by transponders is captured by about 18 inch dish antenna that feeds signal to the set-top-box which converts the signal back to its original format for TV set. It is integrated receiver and decoder gadget, in fact is the heart of the DTH system.

MAIN ADVANTAGES OF DTH TRANSMISSION

1. It facilitates the use of small dish antennas, which could be easily installed in individual homes, and provides a large number of services within the same transponder.
2. The broadcaster would be able to introduce a large number of new interactive applications such as Internet access, e-mail and VOD. It could be even used for public service messages through high powered transponders. The net result will be an increase in customer base.
3. Another benefit of the broadcasters will be that it keeps out intermediaries like cable operators who could distort the subscription income. It is considered the broadcasters best bet for direct access to subscribers with revenue collection alongside.
4. For the viewers the attraction will be the better quality of transmission and the value-addition DTH offers.
5. For public broadcaster like Prasar Bharati, free to air DTH broadcasting has emerged as viable alternative for universal coverage of population with television programmes.

IPTV

Internet Protocol television (IPTV) is a system through which television services are delivered using the Internet protocol suite over a packet-switched network such as the Internet (instead of being delivered through traditional terrestrial, satellite signal, and cable television formats) to provide the required level of quality of service and experience, security, interactivity and reliability. IPTV services may be classified into three main groups:

- Live television, with or without interactivity related to the current TV show;
- Time-shifted television: catch-up TV (replays a TV show that was broadcast hours or days ago), start-over TV (replays the current TV show from its beginning);
- Video on demand (VOD): browse a catalogue of videos, not related to TV programming.

IPTV is distinguished from Internet television by its on-going standardization process (e.g., European Telecommunications Standards Institute) and preferential deployment scenarios in subscriber-based telecommunications networks with high-speed access channels into end-user premises via set-top boxes or other customer-premises equipment.

HYBRID IPTV

Hybrid IPTV refers to the combination of traditional broadcast TV services and video delivered over either managed IP networks or the public Internet. It is an increasing trend in both the consumer and pay TV (operator) markets.

Hybrid IPTV has grown in popularity in recent years as a result of two major drivers. Since the emergence of online video aggregation sites, like YouTube and Vimeo in the mid-2000s, traditional pay TV operators have come under increasing pressure to provide their subscribers with a means of viewing Internet-based video (both professional and user-generated) on their televisions.

A hybrid set-top allows content from a range of sources, including terrestrial broadcast, satellite, and cable, to be brought together with video delivered over the Internet via an Ethernet connection on the device. This enables television viewers to access a greater variety of content on their TV sets, without the need for a separate box for each service.

ADVANTAGES OF IPTV

The Internet protocol-based platform offers significant advantages, including the ability to integrate television with other IP-based services like high speed Internet access and VoIP. A switched IP network also allows for the delivery of significantly **more content and functionality**. In a typical TV or satellite network, using broadcast video technology, all the content constantly flows downstream to each customer, and the customer switches the content at the set-top box. The customer can select from as many choices as the telecomms, cable or satellite company can stuff into the "pipe" flowing into the home. A switched IP network works differently. Content remains in the network, and only the content the customer selects is sent into the customer's home. IPTV technology is bringing **video-on-demand** (VoD) to television, which permits a customer to browse an online program or film catalogue, to watch trailers and to then select a selected recording. The playout of the selected item starts nearly instantaneously on the customer's TV or PC. Another advantage of an IP-based network is the opportunity for **integration and convergence.**

This opportunity is amplified when using IMS-based solutions. Converged services imply interaction of existing services in a seamless manner to create new value added services. One example is on-screen Caller ID, getting Caller ID on a TV and the ability to handle it (send it to voice mail, etc.). IP-based services will help to enable efforts to provide consumers anytime-anywhere access to content over their televisions, PCs and cell phones, and to integrate services and content to tie them together. Within businesses and institutions, IPTV eliminates the need to run a parallel infrastructure to deliver live and stored video services.

DISADVANTAGES OF IPTV

IPTV is sensitive to packet loss and delays if the streamed data is unreliable. IPTV has strict minimum speed requirements in order to facilitate the right number of frames per second to deliver moving pictures. This means that the limited connection speed and bandwidth available for a large IPTV customer base can reduce the service quality delivered. Streaming IPTV across wireless links within the home has proved troublesome; not due to bandwidth limitations as many assume, but due to issues with multipath and reflections of the RF signal carrying the IP data packets. An IPTV stream is sensitive to packets arriving at the right time and in the right order. Improvements in wireless technology are now starting to provide equipment to solve the problem. Due to the limitations of wireless, most IPTV service providers today use wired home networking technologies instead of wireless technologies like 802.11.

P2PTV

The term P2PTV refers to peer-to-peer (P2P) software applications designed to redistribute video streams in real time on a P2P network; the distributed video streams are typically TV channels from all over the world but may also come from other sources. The draw to these applications is significant because they have the potential to make any TV channel globally available by any individual feeding the stream into the network where each peer joining to watch the video is a relay to other peer viewers, allowing a scalable distribution among a large audience with no incremental cost for the source.

TECHNOLOGY AND USE

In a P2PTV system, each user, while downloading a video stream, is simultaneously also uploading that stream to other users, thus contributing to the overall available bandwidth. The arriving streams are typically a few minutes time-delayed compared to the original sources. The video quality of the channels usually depends on how many users are watching; the video quality is better if there are more users. The architecture of many P2PTV networks can be thought of as real-time versions of BitTorrent: if a user wishes to view a certain channel, the P2PTV software contacts a "tracker server" for that channel in order to obtain addresses of peers who distribute that channel; it then contacts these peers to receive the feed. The tracker records the user's address, so that it can be given to other users who wish to view the same channel. In effect, this creates an overlay network on top of the regular internet for the distribution of real-time video content.

VOICE OVER IP (VOIP)

Voice over IP (VoIP) is a family of technologies, methodologies, communication protocols, and transmission techniques for the delivery of voice communications and multimedia sessions over Internet Protocol (IP) networks, such as the Internet. Other terms frequently encountered and often used synonymously with VoIP are *IP telephony*, *Internet telephony*, *voice over broadband* (VoBB), *broadband telephony*, and *broadband phone*.

Internet telephony refers to communications services—voice, fax, SMS, and/or voice-messaging applications—that are transported via the Internet, rather than the public switched telephone network (PSTN). The steps involved in originating a VoIP telephone call are signalling and media channel setup, digitization of the analog voice signal, encoding, packetization, and transmission as Internet Protocol (IP) packets over a packet-switched network. On the receiving side, similar steps (usually in the reverse order) such as reception of the IP packets, decoding of the packets and digital-to-analog conversion reproduce the original voice stream.

Even though IP Telephony and VoIP are terms that are used interchangeably, they are actually different; IP telephony has to do with digital telephony systems that use IP protocols for voice communication, while VoIP is actually a subset of IP Telephony. VoIP is a technology used by IP telephony as a means of transporting phone calls. VoIP is available on many smartphones and Internet devices so that users of portable devices that are not phones, may place calls or send SMS text messages over 3G or Wi-Fi.

ADVANTAGES OF VOIP

There are several advantages of using VoIP, including advanced features that standard telephone systems are not capable of and the ability to have a phone number usually associated with a particular local area anywhere in the world. But the biggest single advantage VoIP has over standard telephone systems is cost. In addition, international calls using VoIP are usually very inexpensive. One other advantage, which will become much more pronounced as VoIP use climbs, calls between VoIP users are usually free

NETWORKING

A network is basically all the components (hardware and software) involved in connecting computers across small and large distances. Networks are used to provide an easy access to information, thus increasing productivity for the users.

LOCAL AREA NETWORK (LAN)

Local Area Network (LAN) is used to connect the devices which are geographically located very close to each other, like in Home, Building itself or Campus environment. LANs are designed to allow resource sharing between personal computer and workstation. Shared resources can be Hardware (Printer, database), software (application programs) or data. LAN network may be very simple depending upon the need and type of technology used. LAN network may be just two computers and a printer, or in an organization where hundreds of computers are interconnected

WIDE AREA NETWORK (WAN)

Wide Area Network (WAN) is used to connect the devices which are geographically located at large distances. WAN can be used to connect two or more LANs together, that may be geographically separated. A WAN can be as complex as the backbones that connect the internet. There are 2 types of WAN: switched WAN and point to point WAN.

Switched WAN connects the end system, which usually comprises a router (internet connecting device) that connects to another LAN or WAN.

The **point to point WAN** is normally a leased line connection which is provided by telephone or cable TV provider that connects home computer or a small LAN to an internet service provider (ISP). This type of WAN is used to provide an internet access.

METROPOLITAN AREA NETWORK (MAN)

Metropolitan Area Network (MAN) is a hybrid between LAN and WAN. Like WAN, MAN usually connects two LANs in same geographical area like two buildings in a city. MAN normally covers area inside the city. Whereas WAN usually gives low to medium speed, MAN provides high speed connection such as T1 (1.54 Mbs). A good example of MAN is part of the telephone company network that can provide a high speed DSL line to the customer.

STORAGE AREA NETWORKS (SANS)

Storage area networks (SANs) provide a high-speed infrastructure to move data between storage devices (like disk drives, disk controllers, and any necessary cabling) and file servers. This infrastructure can be dedicated to just these devices or can include other devices. In this network, fibre channels are used for the connection. A fibre channel is an optical cable that connects the file server, disk controllers, and hard drives at rates exceeding 1 gigabit per second (Gbps).

BLUETOOTH

Bluetooth is a proprietary open wireless technology standard for exchanging data over short distances (using short-wavelength radio transmissions in the ISM band from 2400–2480 MHz) from fixed and mobile devices, creating personal area networks (PANs) with high levels of security. Bluetooth uses a radio technology called frequency-hopping spread spectrum, which chops up the data being sent and transmits chunks of it on up to 79 bands (1 MHz each; centered from 2402 to 2480 MHz) in the range 2,400–2,483.5 MHz (allowing for guard bands).Because the Bluetooth devices use a radio (broadcast) communications system, they do not have to be in visual line of sight of each other. Bluetooth provides a secure way to connect and exchange information between devices such as faxes, mobile phones, telephones, laptops, personal computers, printers, Global Positioning System (GPS) receivers, digital cameras, and video game consoles.

WI-FI

Wi-Fi(Wireless Fidelity) is a popular technology that allows an electronic device to exchange data wirelessly (using radio waves) over a computer network, including high-speed Internet connections."Wi-Fi" is a trademark of the Wi-Fi Alliance and the brand name for products using the IEEE 802.11 family of standards.

A device that can use Wi-Fi (such as a personal computer, video game console, smartphone, tablet, or digital audio player) can connect to a network resource such as the Internet via a wireless network access point. Such an access point (or hotspot) has a range of about 20 meters (65 feet) indoors and a greater range outdoors. Hotspot coverage can comprise an area as small as a single room with walls that block radio waves or as large as many square miles — this is achieved by using multiple overlapping access points.

It can operate at 2.4GHz and 5GHz frequency bands. Wi-Fi in the 2.4 GHz frequency block has slightly better range than Wi-Fi in the 5 GHz frequency block. Wi-Fi allows cheaper deployment of local area networks (LANs). The spaces where cables cannot be run (such as outdoor areas and historical buildings) can host wireless LANs. Wi-Fi Protected Access encryption (WPA2) is considered secure; provided a strong passphrase is used.

BLUETOOTH VERSUS WI-FI

Bluetooth and Wi-Fi have some similar applications: setting up networks, printing, or transferring files. Wi-Fi is intended as a replacement for cabling for general local area network access in work areas. This category of applications is sometimes called wireless local area networks (WLAN). Bluetooth was intended for portable equipment and its applications. The category of applications is outlined as the wireless personal area network (WPAN). Bluetooth is a replacement for cabling in a variety of personally carried applications in any setting and also works for fixed location applications such as smart energy functionality in the home (thermostats, etc.).

Wi-Fi is a wireless version of a common wired Ethernet network, and requires configuration to set up shared resources, transmit files, and to set up audio links (for example, headsets and hands-free devices). Wi-Fi uses the same radio frequencies as Bluetooth, but with higher power, resulting in higher bit rates and better range from the base station.

WIMAX

WiMAX (Worldwide Interoperability for Microwave Access) is a wireless communications standard (IEEE 802.16 now known as Fixed WiMax) designed to provide 30 to 40 megabit-per-second data rates, with the 2011 update providing up to 1 Gbit/s for fixed stations. It is a part of a "fourth generation," or 4G, of wireless-communication technology. WiMax far surpasses the 30-metre wireless range of a conventional Wi-Fi local area network (LAN), offering a metropolitan area network with a signal radius of about 50 km. WiMax offers data-transfer rates that can be superior to conventional cable-modem and Digital Subscriber Line (DSL) connections, however, the bandwidth must be shared among multiple users and thus yields lower speeds in practice.

There is no uniform global licensed spectrum for WiMAX, however the WiMAX Forum has published three licensed spectrum profiles: 2.3 GHz, 2.5 GHz and 3.5 GHz, in an effort to drive standardisation and decrease cost.

USES OF WIMAX

The bandwidth and range of WiMAX make it suitable for the following potential applications:

- Providing portable mobile broadband connectivity across cities and countries through a variety of devices.
- Providing a wireless alternative to cable and digital subscriber line (DSL) for "last mile" broadband access.
- Providing data, telecommunications (VoIP) and IPTV services.
- Providing a source of Internet connectivity as part of a business continuity plan.

WIMAX VERSUS WI-FI

WiMAX is a long range system, covering many kilometres that uses licensed or unlicensed spectrum to deliver connection to a network, in most cases the Internet. Wi-Fi uses unlicensed spectrum to provide access to a local network and is more popular in end user devices. WiMAX uses a quality of service (QoS) mechanism based on connections between the base station and the user device. Each connection is based on specific scheduling algorithms. Whereas Wi-Fi uses contention access i.e. all subscriber stations that wish to pass data through a wireless access point (AP) are competing for the AP's attention on a random interrupt basis. This can cause subscriber stations distant from the AP to be repeatedly interrupted by closer stations, greatly reducing their throughput.

Although Wi-Fi and WiMAX are designed for different situations, they are complementary. WiMAX network operators typically provide a WiMAX Subscriber Unit which connects to the metropolitan WiMAX network and provides Wi-Fi within the home or business for local devices (e.g., Laptops, Wi-Fi Handsets, smartphones) for connectivity. This enables the user to place the WiMAX Subscriber Unit in the best reception area (such as a window), and still be able to use the WiMAX network from any place within their residence.

NEAR FIELD COMMUNICATION (NFC)

NFC is a set of standards for smartphones and similar devices to establish radio communication with each other by touching them together or bringing them into close proximity, usually not more than a few centimetres. Present and anticipated applications include contactless transactions, data exchange, and simplified setup of more complex communications such as Wi-Fi. NFC builds upon RFID (radio frequency identification) systems by allowing two-way communication between endpoints, where earlier systems such as contactless smart cards were one-way only.

NFC enabled smartphones have the potential to replace credit cards. This is because NFC phones pack a smart chip--a complex 80-character code that is really hard to crack. Such a device can safely store confidential credit card details and be handy for purchases on the go. NFC can be deployed in ticketing services, rural banking, interactive and targeted advertising, healthcare, hospitality, libraries and pharmacies. NFC can be used in social networking situations, such as sharing contacts, photos, videos or files, and entering multiplayer mobile games. In fact, an NFC phone could become the single key to access to your car, home and office.

NFC VERSUS BLUETOOTH

Bluetooth like NFC is also a short-range communication technologies but one that allows interaction between communication devices as much as 10 meters apart as opposed to just few centimetres in case of NFC. NFC operates at slower speeds than Bluetooth, but consumes far less power and doesn't require pairing.

NFC sets up faster than standard Bluetooth, but is not faster than Bluetooth low energy. With NFC, instead of performing manual configurations to identify devices, the connection between two NFC devices is automatically established quickly: in less than a tenth of a second. The maximum data transfer rate of NFC (424 kbit/s) is slower than that of Bluetooth V2.1 (2.1 Mbit/s).

HYPERTEXT TRANSFER PROTOCOL (HTTP)

The Hypertext Transfer Protocol (HTTP) is an application protocol for distributed, collaborative, hypermedia information systems. HTTP is the foundation of data communication for the World Wide Web. It is a multi-linear set of objects, building a network by using logical links (the so-called hyperlinks) between the nodes (e.g. text or words). HTTP is the protocol to exchange or transfer hypertext. HTTP is designed to permit intermediate network elements to improve or enable communications between clients and servers.

HTTP resources are identified and located on the network by Uniform Resource Identifiers (URIs)—or, more specifically, Uniform Resource Locators (URLs)—using the http or https URI schemes. URIs and hyperlinks in Hypertext Markup Language (HTML) documents form *webs* of inter-linked hypertext documents.

HYPERTEXT MARKUP LANGUAGE (HTML)

HyperText Markup Language (HTML) is the main markup language for displaying web pages and other information that can be displayed in a web browser.

HTML is written in the form of HTML elements consisting of *tags* enclosed in angle brackets (like <html>), within the web page content. HTML tags most commonly come in pairs like <h1> and </h1>, although some tags, known as *empty elements*, are unpaired, for example <img>. The first tag in a pair is the *start tag*, the second tag is the *end tag* (they are also called *opening tags* and *closing tags*). In between these tags web designers can add text, tags, comments and other types of text-based content.HTML elements form the building blocks of all websites. HTML allows images and objects to be embedded and can be used to create interactive forms.

WORLD WIDE WEB (WWW)

The World Wide Web (WWW or W3), commonly known as the Web, or the "Information Superhighway", is a system of interlinked hypertext documents accessed via the Internet. With a web browser, one can view web pages that may contain text, images, videos, and other multimedia, and navigate between them via hyperlinks.

TOUCH SCREEN

A touchscreen is an electronic visual display that can detect the presence and location of a touch within the display area. The term generally refers to touching the display of the device with a finger or hand. Touchscreens can also sense other passive objects, such as a stylus. Touchscreens are common in devices such as game consoles, all-in-one computers, tablet computers, and smartphones.

The touchscreen has two main attributes. *First*, it enables one to interact directly with what is displayed, rather than indirectly with a pointer controlled by a mouse or touchpad. *Secondly*, it lets one do so without requiring any intermediate device that would need to be held in the hand (other than a stylus, which is optional for most modern touchscreens).

RESISTIVE TOUCHSCREEN

A resistive touchscreen panel comprises several layers, the most important of which are two thin, transparent electrically-resistive layers separated by a thin space. These layers face each other, with a thin gap between. A voltage is passed through one layer, and sensed at the other. When an object, such as a fingertip or stylus tip, presses down on the outer surface, the two layers touch to become connected at that point. The panel then behaves as a pair of voltage dividers, one axis at a time. By rapidly switching between each layer, the position of a pressure on the screen can be read.

Resistive touch is used in restaurants, factories and hospitals due to its high resistance to liquids and contaminants. A major benefit of resistive touch technology is its low cost. Disadvantages include the need to press down and a risk of damage by sharp objects. Resistive touchscreens also suffer from poorer contrast, due to having additional reflections from the extra layer of material placed over the screen.

CAPACITIVE TOUCHSCREEN

A capacitive touchscreen panel consists of an insulator such as glass, coated with a transparent conductor such as indium tin oxide (ITO). As the human body is also an electrical conductor, touching the surface of the screen results in a distortion of the screen's electrostatic field, measurable as a change in capacitance. The location is then sent to the controller for processing. Unlike a resistive touchscreen, one cannot use a capacitive touchscreen through most types of electrically insulating material, such as gloves; one requires a special capacitive stylus, or a special-application glove with an embroidered patch of conductive thread passing through it and contacting the user's fingertip. This disadvantage especially affects usability in consumer electronics, such as touch tablet PCs and capacitive smartphones in cold weather.

MOBILE NUMBER PORTABILITY (MNP)

Mobile Number portability is a service that allows a subscriber to select a new mobile telephone carrier without requiring a new number to be issued. Typically, it is the responsibility of the former carrier to "map" the old number to the undisclosed number assigned by the new carrier. This is achieved by maintaining a database of numbers. A dialled number is initially received by the original carrier and quickly rerouted to the new carrier. Multiple porting references must be maintained even if the subscriber returns to the original carrier. MNP was launched in some parts of India in November 2010 and by January 2011; it was spread across the whole country. The terms and conditions of using an MNP service are as following:

- User will have to obtain a unique porting number by sending a SMS
- The code along with filled forms and valid identity proof documents need to be submitted to the new operator.
- Rs 19 is the switching fee.
- A user can switch after 90 days of a new connection being activated.
- Postpaid users need to clear all dues before applying to switch.
- Prepaid users lose any remaining talk time after switching.

MNP request can be cancelled within 24 hours and a new request should be processed within 7 days.

MOBILE SEVA

Mobile Seva is an UN award-winning e-governance initiative by government of India. The programme was launched in 2011 by Department of Electronics and Information Technology (DeitY). The programme takes benefit of ubiquitous mobile phone use all over India, to enable interaction between the Indian government and its citizens. By the end of May, 2014, more than 1000 government bodies from all over India had integrated their services through Mobile Seva, this integration was enabled through various methods such as text messages, mobile applications Unstructured Supplementary Service Data, and Interactive Voice Response System. The system by May 2014 had delivered 930 million mobile text messages to Indian citizens. 318 "pull based" services were available. The Mobile App Store hosted on the Mobile e-governance Service Delivery Gateway provides 300 mobile applications for 24x7 service. Amongst applications available are those related to tracking of Right to Information, passport applications, status of voters lists, locating of hospitals, police stations, ATMs, post offices, railway stations, hostels, sending of alerts in emergencies, downloading of various statutory documents such as birth, death certificates, pension forms, remote monitoring of health parameters by health professionals, maintenance of health records, processing of loud speaker permits.

M-PESA

M-Pesa (**M** for mobile, ***pesa*** for money) is a mobile-phone based money transfer and micro-financing service, launched in 2007 by Vodafone for Safaricom and Vodacom, the largest mobile network operators in Kenya and Tanzania. M-Pesa, was launched in India as a close partnership with HDFC bank in November 2011. It has since expanded to Afghanistan, South Africa, India and in 2014 to Eastern Europe. M-Pesa allows users with a national ID card or passport to deposit, withdraw, and transfer money easily with a mobile device. M-Pesa is a branchless banking service, meaning that it is designed to enable users to complete basic banking transactions without visiting a bank branch.

M-Pesa customers can deposit and withdraw money from a network of agents that includes airtime resellers and retail outlets acting as banking agents. The service enables its users to deposit and withdraw money, transfer money to other users and non-users, pay bills, purchase airtime and transfer money between the service and, in some markets like Kenya, a bank account.

BLU-RAY DISC (BD)

Blu-ray Disc (BD) is an optical disc storage medium designed to supersede the DVD format. The plastic disc is 120 mm in diameter and 1.2 mm thick, the same size as DVDs and CDs. Conventional Blu-ray Discs contain 25 GB per layer, with dual layer discs (50 GB) being the industry standard for feature-length video discs. Triple layer discs (100 GB) and quadruple layers (128 GB) are available for *BD-XL* re-writer drives.

The major application of Blu-ray Discs is as a medium for video material such as feature films. Besides the hardware specifications, Blu-ray Disc is associated with a set of multimedia formats. Generally these formats allow for the video and audio to be stored with greater definition than on DVD. The name *Blu-ray Disc* refers to the blue laser used to read the disc, which allows information to be stored at a greater density than is possible with the longer-wavelength red laser used for DVDs.

DVD

DVD is an optical disc storage format, invented and developed by Philips, Sony, Toshiba, and Panasonic in 1995. DVDs offer higher storage capacity than Compact Discs while having the same dimensions. Pre-recorded DVDs are mass-produced using moulding machines that physically stamp data onto the DVD. Such discs are known as DVD-ROM, because data can only be read and not written nor erased. Blank recordable DVD discs (DVD-R and DVD+R) can be recorded once using a DVD recorder and then function as a DVD-ROM. Rewritable DVDs (DVD-RW, DVD+RW, and DVD-RAM) can be recorded and erased multiple times.

COMPACT DISC (CD)

The Compact Disc (CD) is an optical disc used to store digital data. It was originally developed to store and play back sound recordings only, but the format was later adapted for storage of data (CD-ROM), write-once audio and data storage (CD-R), rewritable media (CD-RW), Video Compact Discs (VCD), Super Video Compact Discs (SVCD), PhotoCD, PictureCD, CD-i, and Enhanced CD. Standard CDs have a diameter of 120 millimetres (4.7 in) and can hold up to 80 minutes of uncompressed audio or 700 MB (700 × 2^{20} bytes) of data

LCD, LED AND PLASMA TV

For many years, the CRT (Cathode ray tube) technology was the dominant technology in television sets. However, in the past few years, there has been a significant improvement in the technology, which has seen the introduction of LCD, plasma and LED televisions. LCD, LED and plasma TVs have to upscale and de-interlace television pictures, and instead of scanning them directly onto the screen like a CRT television, they store pictures and place them onto the TV screen a frame at a time. Each of these new technologies has its strong points in the method that it displays images, among other features. The features for each type of these technologies are as below.

LIQUID CRYSTAL DISPLAY (LCD) TV

LCD was created to replace the CRT technology. A LCD TV is a significant improvement in the way pictures are displayed due to the mode of display involved. LCD technology uses two major components to display, namely; Cold Cathode Florescent Lamps or CCFLs and molecules of liquid crystals. The CCFLs are used to illuminate the liquid molecules with white light, and as the light passes through, an image is created. A LCD TV has the following advantages over a CRT TV; flat and much lighter, a higher resolution, wider viewing angle of up to 175 degrees, lower power consumption, resistant to 'burn in' due to static images, and are ideal for naturally lit environments. However, there are some disadvantages to this technology such as a low contrast ratio and inability to achieve true black picture quality.

PLASMA TV

The shortcomings of LCD TV led to the development of Plasma Display Panel, otherwise known as a plasma TV. With this technology, images are created from gases containing neon and xenon atoms. Plasma TV technology boasts of a rich variation of colours, due to an advanced colour generation feature, that is able to generate true black picture quality.

The viewing distance and angles are also wider, ranging from 160 and up to 180 degrees, which is more than what can be achieved with a LCD TV. A plasma TV also has a higher lifespan than LCD TV. The downside of this technology is that the viewing capability, especially the brightness is greatly diminished in poor lighting conditions, lower resolution, and an irreparable back light.

LIGHT EMITTING DIODE (LED) TV

A more advanced technology in television display is the LED TV. This is basically an advanced model of a LCD TV, which uses Light Emitting Diodes instead of the traditional Cold Cathode Florescent Lamps for its back light.

The major advantage of using an LED TV is that it eliminated the numerous black spots that were as a result of using fluorescent lights. A LED TV has the best colour levels and contrast ratio, hence superb picture quality that is viewable from wider angles; its power consumption is significantly lower, is shock resistant and longer lasting than its predecessors. The only shortcoming to a LED TV is that it is more expensive than a LCD TV and a plasma TV.

E-GOVERNMENT

E-Government (electronic government, also known as digital government, online government, or connected government) is digital interactions between a government and citizens (G2C), government and businesses/Commerce (G2B), government and employees (G2E), and also between government and governments /agencies (G2G).

This digital interaction consists of governance, information and communication technology (ICT), business process re-engineering (BPR), and e-citizen at all levels of government (city, state/province, national, and international).

Thus, E-Government' can be defined as 'the employment of the Internet and the world-wide-web for delivering government information and services to the citizens.'

DELIVERY MODELS AND ACTIVITIES OF E-GOVERNMENT

The primary delivery models of e-Government can be divided into:

- Government-to-Citizen or Government-to-Consumer (G2C)
- Government-to-Business (G2B)
- Government-to-Government (G2G)
- Government-to-Employees (G2E)

Within each of these interaction domains, four kinds of activities take place:

- pushing information over the Internet, e.g.: regulatory services, general holidays, public hearing schedules, issue briefs, notifications, etc.
- two-way communications between the agency and the citizen, a business, or another government agency. In this model, users can engage in dialogue with agencies and post problems, comments, or requests to the agency.
- conducting transactions, e.g.: lodging tax returns, applying for services and grants.
- governance, e.g.: To enable the citizen transition from passive information access to active citizen participation by informing the citizen, by representing the citizen, by encouraging the citizen to vote, by consulting the citizen and by involving the citizen

DISADVANTAGES

The main disadvantages concerning e-government is the lack of equality in public access to the internet, reliability of information on the web, and hidden agendas of government groups that could influence and bias public opinions. There are many considerations and potential implications of implementing and designing e-government, including disintermediation of the government and its citizens, impacts on economic, social, and political factors, vulnerability to cyber attacks, and disturbances to the *status quo* in these areas.

ADVANTAGES

The ultimate goal of the E-Government is to be able to offer an increased portfolio of public services to citizens in an efficient and cost effective manner. E-government allows for government transparency which allows the public to be informed about what the government is working on as well as the policies they are trying to implement. It is convenient and cost-effective for businesses, and the public benefits by getting easy access to the most current information available without having to spend time, energy and money to get it.

E-government helps simplify processes and makes access to government information more easily accessible for public sector agencies and citizens. E-government allows citizens to interact with computers to achieve objectives at any time and any location, and eliminates the necessity for physical travel to government agents sitting behind desks and windows. Improved accounting and record keeping can be noted through computerization, and information and forms can be easily accessed, equalling quicker processing time.

In India, the e-Governance initiatives are broadly managed under the umbrella of the NeGP initiative.

NATIONAL E-GOVERNANCE PLAN (NEGP)

NeGP is a plan of the Government of India to make all government services available to the citizens of India via electronic medium. This plan was an outcome of the recommendations of the second Administrative Reforms Commission. It is under the administration of the Department of Information Technology.

eGOV KNOWLEDGE EXCHANGE

To assist the government the NISG (a non-profit organisation) started a portal project called eGov Knowledge eXchange. It is a collaborative effort to collect, develop and share knowledge and material on eGovernance initiatives across the different government agencies, state government, union government and private institutions of India. The objective is collective learning from each other's projects and learning lessons. This portal aims to develop knowledge about eGovernance domain from public, private and government levels.

NATIONAL INSTITUTE FOR SMART GOVERNMENT (NISG)

NISG is a non-profit organization incorporated in 2002 by the Government of India and NASSCOM with its head office at Hyderabad, India.

The Government of India is committed to eGovernment in order to make India more competitive in the new global economy. Having a highly developed public service that is capable of delivering eGovernment services to customers is an essential part of that strategy.

The Vision of NISG is "to establish itself as an institution of excellence in e-Governance and to leverage private sector resources through a Public-Private-Partnership mode in establishing eIndia."

DIGITAL INDIA PROGRAMME

Even though India is known as a powerhouse of software, the availability of electronic government services to citizens is still comparatively low. The National e-Governance Plan approved in 2006 has made a steady progress through Mission Mode Projects and Core ICT Infrastructure, but greater thrust is required to ensure effective progress in electronics manufacturing and e-Governance in the country. The Digital India vision provides the intensified impetus for further momentum and progress for this initiative and this would promote inclusive growth that covers electronic services, products, devices, manufacturing and job opportunities. India in the 21st Century must strive to meet the aspirations of its citizens where government and its services reach the doorsteps of citizens and contribute towards a long-lasting positive impact.

The Cabinet on August 20, 2014 at the meeting chaired by the Prime Minister, Shri Narendra Modi gave its approval for Digital India – A programme to transform India into digital empowered society and knowledge economy. This programme has been envisaged by Department of Electronics and Information Technology (DeitY).

The vision of Digital India aims to transform the country into a digitally empowered society and knowledge economy by leveraging IT as a growth engine of new India. The programme will be implemented in phases from the current year till 2019. The Digital India is transformational in nature and would ensure that Government services are available to citizens electronically. It would also bring in public accountability through mandated delivery of government's services electronically, a Unique ID and e-Pramaan based on authentic and standard based interoperable and integrated government applications and data basis.

The project has a total overlay of Rs 1 lakh crore, aims to ensure that government services are available to citizens electronically and help people gain benefits from the latest information and communication technology. The source of funding for most of the e-Governance projects at present is through budgetary provisions of respective Ministries/ Departments in the Central or State governments.

VISION AREAS

I. **Infrastructure as Utility to Every Citizen:**

- High speed internet as a core utility shall be made available in all Gram Panchayats.
- Cradle to grave digital identity - unique, lifelong, online and authenticable.
- Mobile phone and Bank account would enable participation in digital and financial space at individual level.
- Easy access to a Common Service Centre within their locality.
- Shareable private space on a public Cloud.
- Safe and secure Cyber-space in the country.

II. **Governance and Services on Demand:**

- Seamlessly integrated across departments or jurisdictions to provide easy and a single window access to all persons.
- Government services available in real time from online and mobile platforms.
- All citizen entitlements to be available on the Cloud to ensure easy access.
- Government services digitally transformed for improving Ease of Doing Business.
- Making financial transactions above a threshold, electronic and cashless.
- Leveraging GIS for decision support systems and development.

III. Digital Empowerment of Citizens:

- Universal digital literacy.
- All digital resources universally accessible.
- All Government documents/ certificates to be available on the Cloud.
- Availability of digital resources / services in Indian languages.
- Collaborative digital platforms for participative governance.
- Portability of all entitlements for individuals through the Cloud.

SCOPE OF DIGITAL INDIA

The overall scope of this programme is:

- to prepare India for a knowledge future.
- on being transformative that is to realize IT (Indian Talent) + IT (Information Technology) = IT (India Tomorrow)
- making technology central to enabling change.
- on being an Umbrella Programme – covering many departments. The programme weaves together a large number of ideas and thoughts into a single, comprehensive vision, so that each of them is seen as part of a larger goal. Each individual element stands on its own, but is also part of the larger picture. The weaving together makes the Mission transformative in totality.

The Digital India Programme will pull together many existing schemes which would be restructured and re-focused and implemented in a synchronized manner. The common branding of the programmes as Digital India, highlights their transformative impact. Digital India aims to provide the much needed thrust to the **nine pillars of growth areas**, namely

1. Broadband Highways;
2. Universal Access to Mobile Connectivity;
3. Public Internet Access Programme;
4. e-Governance: Reforming Government through Technology;
5. e-Kranti - Electronic Delivery of Services;
6. Information for All;
7. Electronics Manufacturing;
8. IT for Jobs; and
9. Early Harvest Programmes.

APPROACH AND METHODOLOGY

1. Ministries / Departments / States would fully leverage the Common and Support ICT Infrastructure established by the Government of India.
2. The existing/ ongoing e-Governance initiatives would be revamped to align them with

the principles of Digital India. Scope enhancement, Process Reengineering, use of integrated & interoperable systems and deployment of emerging technologies like Cloud & mobile would be undertaken to enhance delivery of Government services to citizens.

3. States would be given flexibility to identify for inclusion additional state-specific projects, which are relevant to their socio-economic needs.
4. e-Governance would be promoted through a centralised initiative to the extent necessary, to ensure citizen centric service orientation.
5. Successes would be identified and their replication promoted proactively.
6. Public Private Partnerships would be preferred wherever feasible.
7. Adoption of Unique ID would be promoted to facilitate identification, authentication and delivery of benefits.
8. Restructuring of NIC would be undertaken to strengthen the IT support to all government departments at the Centre and State levels.
9. The positions of Chief Information Officers (CIO) would be created in at least 10 key ministries so that various e-Governance projects could be designed, developed and implemented faster.
10. DeitY would create necessary senior positions within the department for managing the programme.
11. Central Ministries / Departments and State Governments would have the overall responsibility for implementation of various Mission Mode and other projects under this Programme. Considering the need for overall aggregation and integration at the national level, it is considered appropriate to implement Digital India as a programme with well defined roles and responsibilities of each agency involved.

Besides that a programme management structure would be established for monitoring implementation. The initiative is commendable and deserves full support of all stakeholders. However, the initiative also lacks many crucial components including lack of legal framework, absence of privacy and data protection laws, civil liberties abuse possibilities, lack of parliamentary oversight for e-surveillance in India, lack of intelligence related reforms in India, insecure Indian cyberspace, etc. These issues have to be managed first before introducing DI initiative in India. Digital India project is worth exploring and implementation despite its shortcomings that can be rectified before its implementation.

MYGOV

Prime Minister Narendra Modi launched a website MyGov on July 26, 2014 that aims to help citizens contribute in governance by giving their opinions and views on important issues. At present, there are six groups on the platform – **Clean Ganga**, Girl Child Education, Clean India, Skilled India, Digital India and Job Creation. The inauguration of the people-centric platform also marks the completion of 60 days of the new government.

MyGov (**mygov.nic.in**) is a technology-driven medium that will provide citizens an opportunity to contribute towards good governance. The platform would bridge gulf between people and government. National Informatics Centre (NIC) of the Department of Electronics and Information Technology (DeitY) will implement and manage the platform. It is also an initiative to build a digital knowledge library. The portal can even be extended to act like a public audit platform for government projects such as citizens giving feedback on status of completed infrastructure projects or availability of various social sector programmes. The citizen-centric platform empowers people to connect with the Government & contribute towards good governance.

DIGITAL CLOUD

Prime Minister Narendra Modi's big push to free up service delivery from the hold of the lower bureaucracy will be in the form of a **'digital cloud'** for every Indian. Certificates issued by the government — education, residential, medical records, birth certificates etc — are to be stored in individual 'digital lockers' and a communication protocol established for government departments to access them without physically having to see the hard copy.

The government is working on an ambitious plan to provide each citizen with a "unique digital cloud". It would be your own little bank of information - where all your original documents can be saved. Birth certificate, school certificates, board exam marksheets, college degrees, documents about other qualifications, passport, pan card, residence proof and even property details.

So, if a graduate applies for a government job, "the government can access the applicant's personal digital cloud and get a copy of degree provided by the university," explained a senior NDA minister, citing an example.

As a result, work would be less dependent on paper documents. "It would also save people the trouble of getting documents attested and help stop forgery. If successfully implemented, the digital cloud can have different use in urban and rural context. For the rural population, it could store information regarding government benefits availed by each person – direct cash transfers, medical assistance and subsidies.

GI CLOUD INITIATIVE (MEGHRAJ)

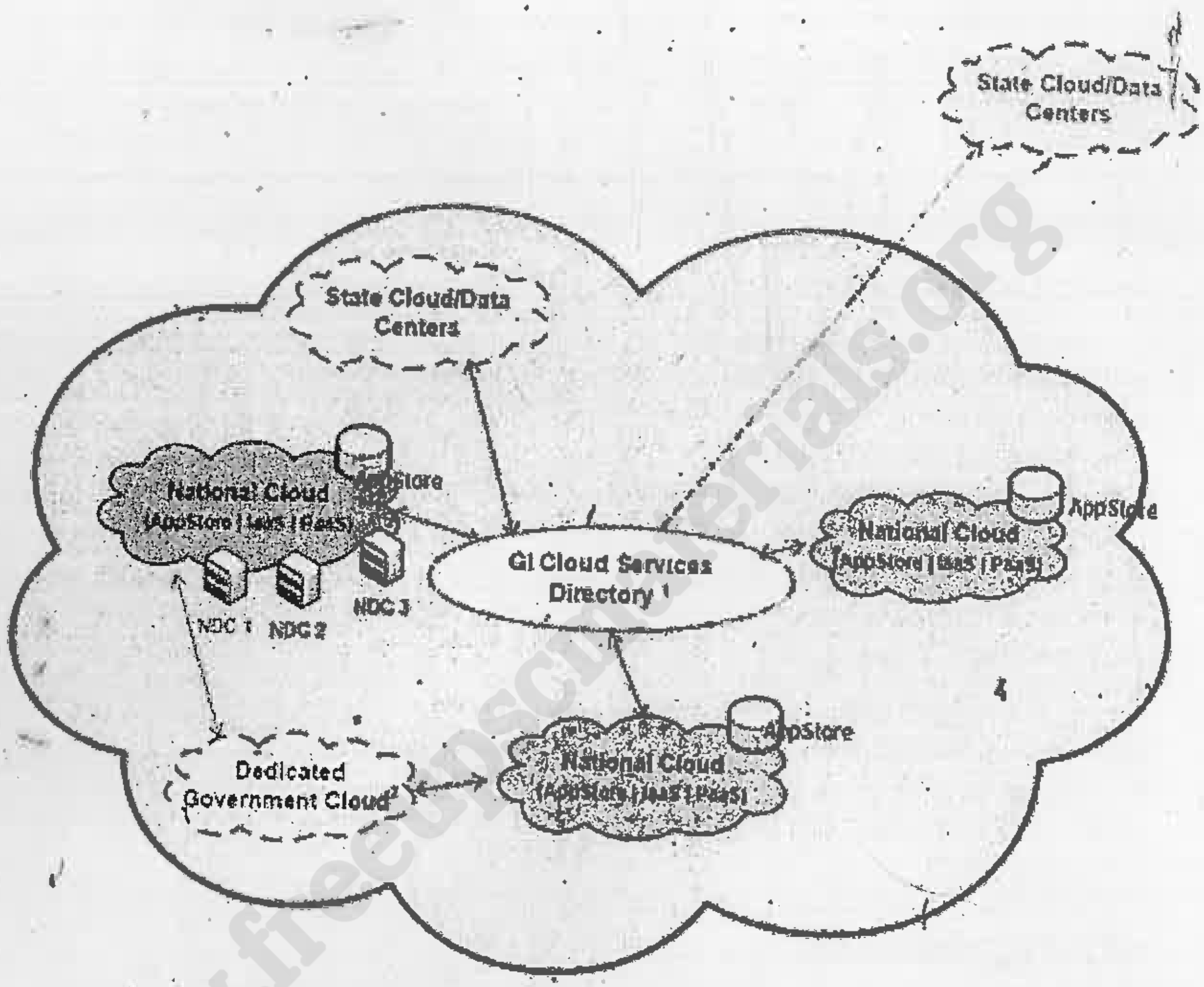
In order to utilize and harness the benefits of Cloud Computing, the Central Government has embarked upon an ambitious initiative – **'GI Cloud'** which has been named as 'MeghRaj'. The project is under the government's 'MeghRaj' Initiative (formerly known as GI Cloud) and is being implemented by NIC.

The focus of this initiative is to accelerate delivery of e-services in the country while optimizing ICT spending of the Government. This will ensure optimum utilization of the infrastructure and speed up the development and deployment of eGov applications.

As per the set of common protocols, guidelines and standards issued by the Government of India, GI cloud will cover a set of discrete cloud computing environments spread across multiple locations, built on existing or new (augmented) infrastructure. Two Policy reports i.e 'GI Cloud Strategic Direction Paper' and 'GI Cloud Adoption and Implementation Roadmap' have been prepared by the Department of Electronics & Information Technology (DeitY).

The National Cloud will help the departments to procure ICT services on demand in the OPEX model rather than investing upfront on the CAPEX. The Cloud Services available are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS) and Storage as a Service (STaaS). Some of the features of the National Cloud include self service portal, multiple Cloud solutions, secured VPN access and multi location Cloud.

(Cloud services are discussed in detail under the topic cloud computing)


State Cloud/Data Centers
State Cloud/Data Centers
National Cloud (AppStore | IaaS | PaaS)
AppStore
NDC 1
NDC 2
NDC 3
GI Cloud Services Directory 1
National Cloud (AppStore | IaaS | PaaS)
AppStore
Dedicated Government Cloud2
National Cloud (AppStore | IaaS | PaaS)
AppStore

BHARAT BILL PAYMENT SYSTEM (BBPS)

The Reserve Bank of India (RBI), on August 8, 2014 issued draft guidelines for the implementation of Bharat Bill Payment System (BPPS). The Bharat Bill Payment System (BBPS) will function as a tiered structure for operating the bill payment system in the country with a single brand image providing convenience of 'anytime anywhere' bill payment to customers.

The centralised bill payments infrastructure will consist of two types of entities carrying out distinct functions –

1. Entity operating the Bharat Bill Payment System (BBPS) which will be the standard setting body, which, inter-alia, will cover standards related to payment, clearing and settlement process and
2. Bharat Bill Payment Operating Units (BBPOUs), which will be the authorised operational units, working in adherence to the standards set by the BBPS. The tiered structure could be further strengthened through an effective establishment of agent

network/s by the BBPOUs.

The participants in the BBPS will include authorised entities, such as, the entity operating the BBPS itself, the BBPOUs as well as their agents, payment gateways, banks, billers and service providers, and other entities as required under the BBPS.

OBJECTIVE OF THE BBPS

The objective of the BBPS is to implement an integrated bill payment system in the country and offer interoperable and accessible bill payment service to customers through a network of agents, enabling multiple payment modes, and providing instant confirmation of payment. Hence, it has been decided that the existing players in the online commerce segment catering to the requirements of bill payments as well as aggregation of payment services (in relation to bill payments) will be a part of BBPS.

SCOPE OF THE BBPS

At present, the online commerce space in the country broadly consists of content providers on the one hand and payment aggregators on the other. While the payment side could include both banks and intermediaries who are facilitating aggregation of payment services, the content side includes a varied set of intermediaries ranging from those who are hosting digital market places to those who are facilitating merchants relating to specific verticals. Some of these intermediaries are also in the business of aggregating bill payments. Similarly, some of the content providers enable payment services through their own arrangements while others use the services of specialised payment aggregators.

In future, the scope of BBPS could be extended to include services facilitating the collection of repetitive payments, such as, school / university fees, municipal taxes/payments etc. and also other e-commerce service content as decided from time to time by the Reserve Bank of India.

NEW TECHNOLOGIES

PROJECT LOON

It is a research and development project being developed by Google with the mission of providing Internet access to rural and remote areas. The project uses high-altitude balloons placed in the stratosphere at an altitude of about 32 km to create an aerial wireless network with up to 3G-like speeds.

The balloons are manoeuvred by adjusting their altitude to float to a wind layer after identifying the wind layer with the desired speed and direction using wind data from the National Oceanic and Atmospheric Administration (NOAA). The users connect to the balloon network using a special Internet antenna attached to their building. The signal travels through the balloon network from balloon to balloon, then to a ground-based station connected to an Internet service provider (ISP), then onto the global Internet.

INTERNET OF THINGS (IOT)

The Internet of Things (IoT) is the interconnection of uniquely identifiable embedded computing devices within the existing Internet infrastructure. Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications (M2M) and covers a variety of protocols, domains, and applications. IoT is a scenario in which objects are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

According to Gartner, there will be nearly 26 billion devices on the Internet of Things by 2020. ABI Research estimates that more than 30 billion devices will be wirelessly connected to the Internet of Things (Internet of Everything) by 2020.

CLOUD COMPUTING

Cloud computing is the delivery of computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a metered service over a network (typically the Internet. This technology allows for much more efficient computing by centralizing storage, memory, processing and bandwidth. End users access cloud based applications while the business software and data are stored on servers at a remote location. Cloud application providers strive to give the same or better service and performance as if the software programs were installed locally on end-user computers.

At the foundation of cloud computing is the broader concept of infrastructure convergence (or Converged Infrastructure) and shared services. This type of data centre environment allows enterprises to get their applications up and running faster, with easier manageability and less maintenance, and enables IT to more rapidly adjust IT resources (such as servers, storage, and networking) to meet fluctuating and unpredictable business demand.

CHARACTERISTICS OF CLOUD COMPUTING

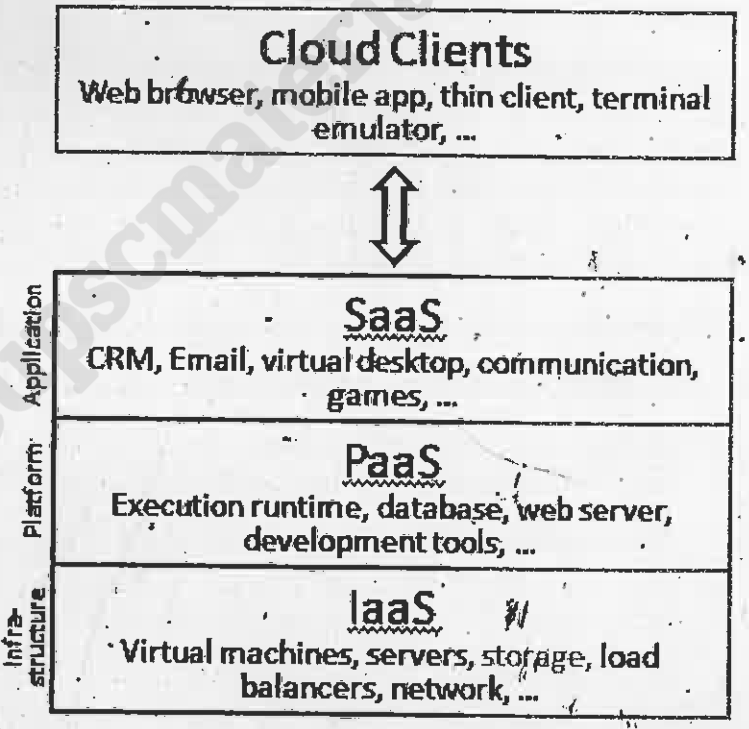
Cloud computing exhibits the following key characteristics:

- **Agility** improves with users' ability to re-provision technological infrastructure resources. Applications can be easily migrated from one physical server to another.
- **Application programming interface** (API) accessibility to software that enables machines to interact with cloud software in the same way the user interface facilitates interaction between humans and computers
- **Cost** is claimed to be reduced and in a public cloud delivery model capital expenditure is converted to operational expenditure. This is purported to lower barriers to entry, as infrastructure is typically provided by a third-party and does not need to be purchased for one-time or infrequent intensive computing tasks. Pricing on a utility computing basis is fine-grained with usage-based options and fewer IT skills are required for implementation (in-house).
- **Device and location independence** enable users to access systems using a web browser regardless of their location or what device they are using (e.g., PC, mobile phone).
- **Multi-tenancy** enables sharing of resources and costs across a large pool of users thus allowing for:
    - **Centralization** of infrastructure in locations with lower costs (such as real estate, electricity, etc.)

  - **Peak-load capacity** increases (users need not engineer for highest possible load-levels)
  - **Utilisation and efficiency** improvements for systems that are often only 10–20% utilised.
- **Scalability** and Elasticity via dynamic ("on-demand") provisioning of resources on a fine-grained, self-service basis near real-time, without users having to engineer for peak loads.
- **Security** could improve due to centralization of data, increased security-focused resources, etc., but concerns can persist about loss of control over certain sensitive data, and the lack of security for stored kernels. Private cloud installations are in part motivated by users' desire to retain control over the infrastructure and avoid losing control of information security.
- **Maintenance** of cloud computing applications is easier, because they do not need to be installed on each user's computer and can be accessed from different places.

SERVICE MODELS

Cloud computing providers offer their services according to three fundamental models: Infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) where IaaS is the most basic and each higher model abstracts from the details of the lower models.


Cloud Clients
Web browser, mobile app, thin client, terminal emulator, ...
Application
SaaS
CRM, Email, virtual desktop, communication, games, ...
Platform
PaaS
Execution runtime, database, web server, development tools, ...
Infra-structure
IaaS
Virtual machines, servers, storage, load balancers, network, ...

INFRASTRUCTURE AS A SERVICE (IAAS)

In this most basic cloud service model, cloud providers offer computers – as physical or more often as virtual machines –, raw (block) storage, firewalls, load balancers, and networks. IaaS providers supply these resources on demand from their large pools installed in data centres. Local area networks including IP addresses are part of the offer. For the wide area connectivity, the Internet can be used or - in carrier clouds - dedicated virtual private networks can be configured.

To deploy their applications, cloud users then install operating system images on the machines as well as their application software. In this model, it is the cloud user who is responsible for patching and maintaining the operating systems and application software. Cloud providers typically bill IaaS services on a utility computing basis, that is, cost will reflect the amount of resources allocated and consumed.

PLATFORM AS A SERVICE (PAAS)

In the PaaS model, cloud providers deliver a computing platform and/or solution stack typically including operating system, programming language execution environment, database, and web server. Application developers can develop and run their software solutions on a cloud platform without the cost and complexity of buying and managing the underlying hardware and software layers. With some PaaS offers, the underlying compute and storage resources scale automatically to match application demand such that the cloud user does not have to allocate resources manually.

SOFTWARE AS A SERVICE (SAAS)

In this model, cloud providers install and operate application software in the cloud and cloud users access the software from cloud clients. The cloud users do not manage the cloud infrastructure and platform on which the application is running. This eliminates the need to install and run the application on the cloud user's own computers simplifying maintenance and support. What makes a cloud application different from other applications is its elasticity. This can be achieved by cloning tasks onto multiple virtual machines at run-time to meet the changing work demand. Load balancers distribute the work over the set of virtual machines. This process is transparent to the cloud user who sees only a single access point. To accommodate a large number of cloud users, cloud applications can be multitenant, that is, any machine serves more than one cloud user organization.

ISSUES RELATED TO CLOUD COMPUTING

As cloud computing is achieving increased popularity, concerns are being voiced about the security issues introduced through adoption of this new model. The effectiveness and efficiency of traditional protection mechanisms are being reconsidered as the characteristics of this innovative deployment model can differ widely from those of traditional architectures. An alternative perspective on the topic of cloud security is that this is but another, although quite broad, case of "applied security" and that similar security principles that apply in shared multi-user mainframe security models apply with cloud security.

The relative security of cloud computing services is a contentious issue that may be delaying its adoption. Physical control of the Private Cloud equipment is more secure than having the equipment off site and under someone else's control. Physical control and the ability to visually inspect the data links and access ports is required in order to ensure data links are not compromised.

CHAPTER – 7

COMPUTER GLOSSARY

Internet Protocol (IP): IP is the principal communications protocol used for relaying datagrams (also known as network packets) across an internetwork using the Internet Protocol Suite. It helps in delivering datagrams from the source host to the destination host solely based on the addresses. It also defines addressing methods that are used to label the datagram source and destination. The first major version of IP, Internet Protocol Version 4 (IPv4), is the dominant protocol of the internet. Its successor is Internet Protocol Version 6 (IPv6), which is increasing in use.

Internet Protocol address: An IP address is a numerical label assigned to each device (e.g., computer, printer) participating in a computer network that uses the Internet Protocol for communication. An IP address serves two principal functions: host or network interface identification and location addressing. The designers of the Internet Protocol defined an IP address as a 32-bit number and this system, known as Internet Protocol Version 4 (IPv4), was in use for a long time. However, due to the enormous growth of the Internet and the predicted depletion of available addresses, a new version of IP (IPv6), using 128 bits for the address, was developed in 1995 and is presently in use.

Internet Protocol version 4 (IPv4): IPv4 is the fourth revision in the development of the Internet Protocol (IP) and the first version of the protocol to be widely deployed. Together with IPv6, it is at the core of standards-based internetworking methods of the Internet.

Internet Protocol version 6 (IPv6): IPv6 is a revision of the Internet Protocol (IP) developed by the Internet Engineering Task Force (IETF). IPv6 is intended to succeed IPv4. IPv6 was developed to deal with the long-anticipated problem of IPv4 running out of addresses. IPv6 implements a new addressing system that allows for far more addresses to be assigned than with IPv4. IPv6 uses 128-bit addresses, allowing for 2^{128}, or approximately 3.4×10^{38} addresses. World IPv6 Launch took place in 2012.

Generic Top-Level Domain (gTLD): gTLD is one of the categories of top-level domains (TLDs) maintained by the Internet Assigned Numbers Authority (IANA) for use in the Domain Name System of the Internet. The core group of generic top-level domains consists of the com, info, net, and org domains. In addition, the domains biz, name, and pro are also considered generic; however, these are designated as restricted, because registrations within them require proof of eligibility within the guidelines set for each.

Virtual Private Network (VPN): VPN is a private network that interconnects remote (and often geographically separated) networks through primarily public communication infrastructures such as the Internet. VPNs provide security through tunnelling protocols and security procedures such as encryption. For example, a VPN could be used to securely connect the branch offices of an organization to a head office network through the public Internet. A VPN can also be used to interconnect two similar-type networks over a dissimilar middle network for example, two IPv6 networks over an IPv4 network.

There are two main types of VPN: remote-access VPNs and Site-to-site VPNs. **Remote-access** VPNs allow individual users to connect to a remote network such as roaming salespeople connecting to their company's intranet. Site-to-site VPNs allow inter-connection of networks of multiple users for example, branch offices to the main company network. VPNs hence reduce costs as they eliminate the need for dedicated leased lines between networks, but instead use existing infrastructures to connect networks while adding a layer of security.

World Wide Web (WWW): The World Wide Web (commonly known as the Web), is a system of interlinked hypertext documents accessed via the Internet. With a web browser, one can view web pages that may contain text, images, videos, and other multimedia, and navigate between them via hyperlinks.

Internet: The Internet is a global system of interconnected computer networks that use the standard Internet protocol suite to serve billions of users worldwide. It is a *network of networks* that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless and optical networking technologies. The Internet carries an extensive range of information resources and services, such as the inter-linked hypertext documents of the World Wide Web (WWW) and the infrastructure to support email.

Li-Fi: Li-Fi is bidirectional, high speed and fully networked wireless communications, like Wi-Fi, using visible light. Li-Fi is a subset of visible light communications (VLC) and can be a complement to RF communication (Wi-Fi or Cellular network), or a replacement in contexts of data broadcasting. It is wireless and uses visible light communication (instead of radio frequency waves), part of Optical wireless communications technology, which carries much more information, and has been proposed as a solution to the RF-bandwidth limitations. A complete solution includes an industry led standardization process.

The technology was demonstrated at the 2012 Consumer Electronics Show in Las Vegas using a pair of Casio smartphones to exchange data using light of varying intensity given off from their screens, detectable at a distance of up to ten metres. Li-Fi has the advantage of being able to be used in sensitive areas such as in aircraft without causing interference. However, the light waves used cannot penetrate walls.

Digital currency or digital money: It is a form of currency or medium of exchange that is electronically created and stored (i.e., distinct from physical, such as banknotes and coins). Some digital currencies, such as bitcoin, are cryptocurrencies. Both virtual currencies and cryptocurrencies are types of digital currencies, but the converse is incorrect. Like traditional money these currencies may be used to buy physical goods and services but could also be restricted to certain communities such as for example for use inside an on-line game or social network. Digital currencies such as bitcoin are known as "decentralized digital currencies," meaning that there is no central point of control over the money supply.

THREATS TO COMPUTERS:

Spyware: It is a type of malware (malicious software) installed on computers that collects information about users without their knowledge. The presence of spyware is typically hidden from the user and can be difficult to detect.

While the term spyware suggests software that monitors a user's computing, the functions of spyware can extend beyond simple monitoring. Spyware can collect almost any type of data, including personal information like Internet surfing habits, user logins, and bank or credit account information. Spyware can also interfere with user control of a computer by installing additional software or redirecting Web browsers. Some spyware can change computer settings, which can result in slow Internet connection speeds, unauthorized changes in browser settings, or changes to software settings.

Phishing: Phishing is attempting to acquire information (and sometimes, indirectly, money) such as usernames, passwords, and credit card details by masquerading as a trustworthy entity in an electronic communication. Communications purporting to be from popular social web sites, auction sites, online payment processors or IT administrators are commonly used to lure the unsuspecting public. Phishing emails may contain links to websites that are infected with malware. Phishing is typically carried out by e-mail spoofing or instant messaging, and it often directs users to enter details at a fake website whose look and feel are almost identical to the legitimate one. Phishing is an example of social engineering techniques used to deceive users, and exploits the poor usability of current web security technologies.

Voice phishing/Vishing: It is the criminal practice of using social engineering over the telephone system to gain access to private personal and financial information from the public for the purpose of financial reward. Voice phishing exploits the public's trust in landline telephone services, which have traditionally terminated in physical locations known to the telephone company, and associated with a bill-payer. Voice phishing is typically used to steal credit card numbers or other information used in identity theft schemes from individuals. Voice phishing is difficult for legal authorities to monitor or trace. To protect themselves, consumers are advised to be highly suspicious when receiving messages directing them to call and provide credit card or bank numbers — vishers can in some circumstances intercept calls that consumers make when trying to confirm such messages.

SMS Phising: In computing, SMS phishing is a form of criminal activity using social engineering techniques. Phishing is the act of attempting to acquire personal information such as passwords and credit card details by masquerading as a trustworthy entity in an electronic communication. SMS phishing uses cell phone text messages to deliver the *bait* to induce people to divulge their personal information.

Malware: Malware, **(malicious software)**, is software used or created by hackers to disrupt computer operation, gather sensitive information, or gain access to private computer systems. While it is often software, it can also appear in the form of scripts or code. Malware includes computer viruses, worms, trojan horses, spyware, adware, most rootkits, and other malicious programs. Malware is not the same as defective software, which is software that has a legitimate purpose but contains harmful bugs that were not noticed before release. However, some malware is disguised as genuine software, and may come from an official company website. An example would be software used for harmless purposes that also includes tracking software to gather marketing statistics for advertising by the software producer.

Computer Virus: A programme designed as a prank or as a sabotage that replicates itself by attaching to other programmes and carrying out unwanted and sometimes dangerous operation. Internet technologies have made the connected computer more vulnerable to be attacked by virus.

Viruses are sometimes confused with worms and Trojan horses, which are technically different. A worm can exploit security vulnerabilities to spread itself automatically to other computers through networks, while a Trojan horse is a program that appears harmless but hides malicious functions. Worms and Trojan horses, like viruses, may harm a computer system's data or performance.

Internet Worm: It is a program that replicates from machine to machine over the internet, clogging it as it spreads.

Trojan Horse: A Trojan horse, or Trojan, is a standalone malicious file or program that does not attempt to inject itself into other files unlike a computer virus and often masquerades as a legitimate file or program. Trojan horses can make copies of themselves, steal information, or harm their host computer systems. Unlike computer virus, Trojan horse cannot replicate themselves.

Denial-of-service **attack (DoS attack):** In computing, a denial-of-service attack (DoS attack) or distributed denial-of-service attack (DDoS attack) is an attempt to make a machine or network resource unavailable to its intended users. Although the means to carry out, motives for, and targets of a DoS attack may vary, it generally consists of the efforts of one or more people to temporarily or indefinitely interrupt or suspend services of a host connected to the Internet.

Perpetrators of DoS attacks typically target sites or services hosted on high-profile web servers such as banks, credit card payment gateways, and even root nameservers. The term is generally used relating to computer networks, but is not limited to this field; for example, it is also used in reference to CPU resource management.

E-Commerce: It is electronic mode of doing business. It is transmission of information of products/services and of payment through telephone lines, networks or any other medium.

E-Books: It is electronic or digital version of a printed book. It is based either on HTML or PML (Peanut Markup Language).

Electronic money: It is also known as e-currency, e-money, electronic cash, electronic currency, digital money, digital cash, digital currency, cyber currency. E-money is money or scrip that is only exchanged electronically. Typically, this involves the use of computer networks, the internet and digital stored value systems. Electronic funds transfer (EFT), direct deposit, digital gold currency and virtual currency are all examples of electronic money.

Digital Signature: It is also known as electronic signature. An encrypted tamper-proof attestation that is usually attached to encrypted e-mail message or a certificate. It is used to guarantee that a document has not been altered.

CHAPTER – 8

ROBOTICS

A robot is a mechanical or virtual intelligent agent that can perform tasks automatically or with guidance, typically by remote control. It is basically a motorized computer-controlled machine that can be programmed to do a variety of tasks especially repeatable and tiresome ones. The word 'robot' came from 'robota', which means 'forced labour' or 'compulsory service'. Robotics is the branch of technology that deals with the design, construction, operation, structural disposition, manufacture and application of robots and computer systems for their control, sensory feedback, and information processing. The word 'robotics' was used for the first time in print by **Isaac Asimov**.

The first digitally operated and programmable robot, the Unimate, was installed in 1961 to lift hot pieces of metal from a die casting machine and stack them. Today, commercial and industrial robots are in widespread use performing jobs more cheaply and with greater accuracy and reliability than humans. They are also employed for jobs which are too dirty, dangerous or dull to be suitable for humans. Robots are widely used in manufacturing, assembly and packing, transport, earth and space exploration, surgery, weaponry, laboratory research, safety, and mass production of consumer and industrial goods.

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ROBOTIC ASPECTS:

- Robots all have some kind of mechanical construction, a frame, form or shape designed to achieve a particular task.
- Robots have electrical components which power and control the machinery.
- All robots contain some level of computer programming code.

There are three different types of robotic programs: remote control, artificial intelligence and hybrid. A robot with remote control programing has a preexisting set of commands that it will only perform if and when it receives a signal from a control source, typically a human being with a remote control. It is perhaps more appropriate to view devices controlled primarily by human commands as falling in the discipline of automation rather than robotics. Robots that use artificial intelligence interact with their environment on their own without a control source, and can determine reactions to objects and problems they encounter using their preexisting programming. Hybrid is a form of programming that incorporates both AI and RC functions.

Control:

The mechanical structure of a robot must be controlled to perform tasks. The control of a robot involves three distinct phases – perception, processing, and action (robotic paradigms).

- Sensors give information about the environment or the robot itself (e.g. the position of its joints or its end effector). This information is then processed to be stored or transmitted, and to calculate the appropriate signals to the actuators (motors) which move the mechanical.
- The processing phase can range in complexity.

- At a reactive level, it may translate raw sensor information directly into actuator commands. Sensor fusion may first be used to estimate parameters of interest (e.g. the position of the robot's gripper) from noisy sensor data. An immediate task (such as moving the gripper in a certain direction) is inferred from these estimates. Techniques from control theory convert the task into commands that drive the actuators.

At longer time scales or with more sophisticated tasks, the robot may need to build and reason with a "cognitive" model. Cognitive models try to represent the robot, the world, and how they interact. Pattern recognition and computer vision can be used to track objects. Mapping techniques can be used to build maps of the world. Finally, motion planning and other artificial intelligence techniques may be used to figure out how to act.

Autonomy levels: Control systems may also have varying levels of autonomy.

- Direct interaction is used for haptic or tele-operated devices, and the human has nearly complete control over the robot's motion.
- Operator-assist modes have the operator commanding medium-to-high-level tasks, with the robot automatically figuring out how to achieve them.
- An autonomous robot may go for extended periods of time without human interaction. Higher levels of autonomy do not necessarily require more complex cognitive capabilities. For example, robots in assembly plants are completely autonomous, but operate in a fixed pattern.

Applications of Robotics in various fields:

Robotics is an area of interest to human beings for more than one hundred years. On the other hand, our perception over robots is influenced by the media and international film industry (Hollywood). You may ask- what robotics is all about? In my views, a robot's distinctiveness transforms depending on the atmosphere it works in. Some of these are as follows:-

- **Outer Space** – Robotic arms that are under the control of a human being are employed to unload the docking cove of outer-space shuttles to launch satellites or to build a space station.
- **The Intelligent Home** – Robotic systems can nowadays scrutinize home safety, ecological circumstances and energy consumption. Door & windows can be unlocked mechanically and electrical device such as lights and A/C can be pre-programmed to turn on. This helps residents to enjoy appliances irrespective of their mobility.
- **Exploration** – Robots can enter the environments that are injurious to human beings. An illustration is observing the atmosphere within a volcano or investigating our deep marine life. NASA has utilized robotic probe for environmental study, ever since the early 60's.
- **Farms** – Programmed robots are used by harvesters to cut and collect crops. Robotic milk farms are existing permitting workers to nourish and milk their cattle distantly.

- **The Car Industry** – Robotic arms are used, these arms are able to execute numerous tasks in the car manufacturing & assembling procedure. They carry out jobs such as sorting, cutting, welding, lifting, painting and bending
- **Disaster Areas** – Observation robots built-in with superior sensing and imaging gears. This robot can work in dangerous environments like urban site spoiled by earthquakes by inspecting floors, walls, and roofs for structural reality.
- **Entertainment** – Interactive robots that shows behaviors and education capability. One such robot is owned by SONY which moves around freely, responds to all your commands, carries your luggage and even responds to your oral instructions.
- **Industrial robots** – These robots bring into play in an industrialized manufacturing atmosphere. Typically these are articulated arms particularly created for applications like- material handling, painting, welding and others. If we evaluate merely by application then this sort of robots can also consist of some automatically guided automobiles and other robots.
- **Domestic or household robots** – Robots which are used at home. This sort of robots consists of numerous different gears for example- robotic pool cleaners, robotic sweepers, robotic vacuum cleaners, robotic sewer cleaners and other robots that can perform different household tasks.
- **Medical robots** – Robots employed in medicine and medicinal institutes. First & foremost surgical treatment robots. Also, a number of robotic directed automobiles and perhaps lifting supporters.
- **Service robots** – Robots that cannot be classed into any other types by practice. These could be various data collecting robots, robots prepared to exhibit technologies, robots employed for research, etc.
- **Military robots** – Robots brought into play in military & armed forces. This sort of robots consist of bomb discarding robots, various shipping robots, exploration drones. Flying robot drones are brought into play for close watch in present time's modern armed force. In the future robotic airplane and automobiles could be employed to transmit petroleum, bullets, bombs, etc or clear minefields.
- **Space robots** – Robots employed in space as a split apart type. This type of robots would consist of the robots employed on Canadarm that was brought into play in space Shuttles, the International Space Station, together with Mars explorers and other robots employed in space exploration & other activities.

ROBOTICS IN INDIA

Centre for Artificial Intelligence and Robotics (CAIR), Bangalore has developed a variety of controllers and manipulators for Gantry, SCARA and other types of robots. These were supplied to Public Sector Units such as HAL and sister DRDO labs. CAIR has gone on to develop a prototype Unmanned Ground Vehicle (UGV) with the aim of attaining autonomous capability. This involved in- house construction of mobile robot platforms, integration of infrared sensors with the vehicle, and the development and integration of path planning software. A useful offshoot of this work was the development of an intelligent wheelchair that would help physically challenged people both in hospitals and homes. One version of the wheelchair could be operated using human voice commands. Another was equipped with a camera system to get information about the surrounding space for its path planning. CAIR has developed CHATUR Robot with vision sensors which can pick objects in its visual field. Other premier institute where Robotics Research is going on is: Centre for Robotics and Mechanotronics, IIT, Kanpur.

HUMANOID ROBOT

A humanoid robot or an anthropomorphic robot is a robot with its overall appearance, based on that of the human body, allowing interaction with made-for-human tools or environments. In general humanoid robots have a torso with a head, two arms and two legs, although some forms of humanoid robots may model only part of the body, for example, from the waist up. Some humanoid robots may also have a 'face', with 'eyes' and 'mouth'. Androids are humanoid robots built to aesthetically resemble a human. A humanoid robot is an autonomous robot, because it can adapt to changes in its environment or itself and continue to reach its goal. This is the main difference between humanoid and other kinds of robots. The capacities of a humanoid robot include:

- self-maintenance (i.e. recharging itself)
- autonomous learning (learn or gain new capabilities without outside assistance, adjust strategies based on the surroundings and adapt to new situations)
- avoiding harmful situations to people, property, and itself
- safe interacting with human beings and the environment

PURPOSE OF HUMANOID ROBOTS

Humanoid robots are used as a research tool in several scientific areas. Researchers need to understand the human body structure and behaviour (biomechanics) to build and study humanoid robots. On the other side, the attempt to simulate the human body leads to a better understanding of it. Human cognition is a field of study which is focused on how humans learn from sensory information in order to acquire perceptual and motor skills. This knowledge is used to develop computational models of human behaviour and it has been improving over time.

Although the initial aim of humanoid research was to build better orthosis and prosthesis for human beings, knowledge has been transferred between both disciplines. A few examples are: powered leg prosthesis for neuromuscularly impaired, ankle-foot orthosis, biological realistic leg prosthesis and forearm prosthesis. Besides the research, humanoid robots are being developed to perform human tasks like personal assistance, where they should be able to assist the sick and elderly, and dirty or dangerous jobs. Regular jobs like being a receptionist or a worker of an automotive manufacturing line are also suitable for humanoids. In essence, since they can use tools and operate equipment and vehicles designed for the human form, humanoids could theoretically perform any task a human being can. Humanoid robots, especially with artificial intelligence algorithms, could be useful for future dangerous and/or distant space exploration missions, without having the need to turn back around again and return to Earth once the mission is completed.

CHAPTER – 9

NANOTECHNOLOGY

Nanotechnology is molecular manufacturing or more simply, building things the size of one atom or one molecule with programmed precision. It involves working with matter at the scale of one-billionth of a meter (1 nm = 10-9 m). The idea of nanotechnology is therefore to master the characteristics of matter in an intelligent manner to develop highly efficient system. It is an interesting confluence of biology, chemistry & electronics. The trick is to manipulate atoms individually and place them where needed, to produce the desired structure. Therefore, it is often termed as the 'bottom-up" manufacturing. The concept was conceived in 1959 by Nobel Laureate – physicist Richard P. Feynman.

Nanotechnology can be used to create many new materials and devices with a vast range of applications, such as in medicine, electronics, biomaterials and energy production. On the other hand, nanotechnology raises many of the same issues as any new technology, including concerns about the toxicity and environmental impact of nanomaterials, and their potential effects on global economics, as well as speculation about various doomsday scenarios. These concerns have led to a debate among advocacy groups and governments on whether special regulation of nanotechnology is warranted.

Nanoscience: It is a term used to describe the inter-disciplinary fields of science devoted to the study of nanoscale phenomena employed in Nanotechnology.

Molecular Nanotechnology (MNT): It is an anticipated manufacturing technology that would allow precise control and positional assembly of molecule-sized building blocks through the use of nano-scale manipulator arms. It is considered distinct from more inclusive term nanotechnology. These microscopic devices would manipulate individual atoms and molecules for variety of applications.

Applications of Nano technology:

1. Nanotechnology in Medicine:

- One application of nanotechnology in medicine currently being developed involves employing nanoparticles to deliver drugs, heat, light or other substances to specific types of cells (such as cancer cells). Particles are engineered so that they are attracted to diseased cells, which allows direct treatment of those cells.
- This technique reduces damage to healthy cells in the body and allows for earlier detection of disease. For example, nanoparticles that deliver chemotherapy drugs directly to cancer cells are under development. Tests are in progress for targeted delivery of chemotherapy drugs and their final approval for their use with cancer patients is pending.
- Nanoparticles that release drugs when subjected to sheer force, such as occur when passing through a section of artery that is mostly blocked by a clot. This method is effective in delivering drugs used to dissolve clots.
- Gelatin nanoparticles can be used to deliver drugs to damaged brain tissue more efficiently than standard methods. This method will result in more effective drug

delivery for brain injuries.

- A sponge-like matrix that contains insulin as well as Nano capsules containing Hydrogen ions. When the glucose level rises the Nano capsules release hydrogen ions, which bind to the fibers making up the matrix. The hydrogen ions make the fibers positively charged, repelling each other and creating openings in the matrix through which insulin is released. This procedure is more effective as it releases insulin only when the glucose levels are high.
- Nanoparticle that can be taken orally and pass through the lining of the intestines into the bloodstream.
- Nano particles that delivers an enzyme that prevents the reproduction of viruses molecules in the patients' bloodstream.
- "Nano sponges" that absorb toxins and remove them from the bloodstream. The Nano sponges are polymer nanoparticles coated with a red blood cell membrane. The red blood cell membrane allows the Nano sponges to travel freely in the bloodstream and Nano sponges attract the toxins.
- Bismuth nanoparticles to concentrate radiation used in radiation therapy to treat cancer tumors. Initial results indicate that the bismuth nanoparticles would increase the radiation dose to the tumor by 90 percent.
- Targeted heat therapy is being developed to destroy breast cancer tumors. In this method antibodies that are strongly attracted to proteins produced in one type of breast cancer cell are attached to nanotubes, causing the nanotubes to accumulate at the tumor. Infrared light from a laser is absorbed by the nanotubes and produces heat that incinerates the tumor.
- Microbivores: Nano sized artificial Mechanical Phagocytes That digest the infectious bacteria in the patient's body.

2. Nanotechnology in Electronics: Nanoelectronics

Nanoelectronics hold some answers for how we might increase the capabilities of electronics devices while we reduce their weight and power consumption. Some of the applications are given below.

- Integrating silicon nanophotonics components into CMOS (Complementary metal oxide semiconductor) integrated circuits. This optical technique is intended to provide higher speed data transmission between integrated circuits than is possible with electrical signals.
- A low power method to use nanomagnets as switches, like transistors, in electrical circuits. This method might lead to electrical circuits with much lower power consumption than transistor based circuits.
- Another idea is to print prototype circuit boards using standard inkjet printers to form the conductive lines needed in circuit boards.
- Building transistors from carbon nanotubes to enable minimum transistor dimensions of a few nanometers and developing techniques to manufacture integrated circuits built with nanotube transistors.

- Using electrodes made from nanowires that would enable flat panel displays to be flexible as well as thinner than current flat panel displays.
- Using semiconductor nanowires to build transistors and integrated circuits.
- Using carbon nanotubes to direct electrons to illuminate pixels, resulting in a lightweight, millimeter thick "nanoemmissive" display panel.
- Using nanosized magnetic rings to make Magnetoresistive Random Access Memory (MRAM)which research has indicated may allow memory density of 400 GB per square inch.

3. Nanotechnology in Food

- Storage bins are being produced with silver nanoparticles embedded in the plastic. The silver nanoparticles kill bacteria from any material that was previously stored in the bins, minimizing health risks from harmful bacteria.
- Using silicate nanoparticles to provide a barrier to gasses (for example oxygen), or moisture in a plastic film used for packaging. This could reduce the possibly of food spoiling or drying out.
- Pesticides encapsulated in nanoparticles; that only release pesticide within an insect's stomach, minimizing the contamination of plants themselves.
- Another development being pursued is a network of nanosensors and dispensers used throughout a farm field. The sensors recognize when a plant needs nutrients or water, before there is any sign that the plant is deficient. The dispensers then release fertilizer, nutrients, or water as needed, optimizing the growth of each plant in the field one by one.

4. Nanotechnology in Fuel Cells

- It can reduce the amount of platinum needed in the fuel cells.
- The storage of hydrogen in graphene (single atom thick carbon sheets). The researchers found that they could store14% by weight of hydrogen in graphene.

5. Nanotechnology in Space

- Employing materials made from carbon nanotubes to reduce the weight of spaceships
- Including layers of bio-nano robots in spacesuits. The outer layer of bio-nano robots would respond to damages to the spacesuit, for example to seal up punctures. An inner layer of bio-nano robots could respond if the astronaut was in trouble, for example by providing drugs in a medical emergency.
- Deploying a network of nanosensors to search large areas of planets such as Mars for traces of water or other chemicals.
- Using carbon nanotubes to build lightweight solar sails that use the pressure of light from the sun reflecting on the mirror-like solar cell to propel a spacecraft. This solves the problem of having to lift enough fuel into orbit to power spacecraft during interplanetary missions.
- Working with nanosensors to monitor the levels of trace chemicals in spacecraft to

monitor the performance of life support systems.

6. Nanotechnology in making efficient fuels

- Nanotechnology, in the form of genetic engineering, can also improve the performance of enzymes used in the conversion of cellulose into ethanol.

7. Nanotechnology in reducing air Pollution

There are two major ways in which nanotechnology is being used to reduce air pollution:

- Nanotechnology can improve the performance and cost of catalysts used to transform vapors escaping from cars or industrial plants into harmless gasses. That's because catalysts made from nanoparticles have a greater surface area to interact with the reacting , which makes the catalyst more effective.
- Nanostructured membranes are being developed to separate carbon dioxide from industrial plant exhaust streams.

8. Nanotechnology in reducing water pollution

Nanotechnology is being used to develop solutions to different problems in water quality.

- Nanoparticles can be used to convert the contaminating chemicals in the industrial water through a chemical reaction to make it harmless. Studies have shown that this method can be used successfully to reach contaminates dispersed in underground ponds and at much lower cost than methods which require pumping the water out of the ground for treatment.
- A deionization method using electrodes composed of nano-sized fibers can be used for reducing the cost and energy requirements of turning salt water into drinking water.
- A filter only a few nanometers in diameter is currently being developed that should be capable of removing viruses from water.
- Using nano scavengers, in which a layer of reactive nanoparticles coat a synthetic core which is designed to be easily magnetized. The nanoparticles, for example silver nanoparticles attach to and kill the bacteria. Then when a magnetic field is applied the nano scavengers are removed from the water.
- Using pellets containing nano structured palladiumand gold as a catalyst to breakdown chlorinated compounds contaminating groundwater. Since palladium is very expensive the researchers formed the pellets of nanoparticles that allow almost every atom of palladium to react with the chlorinated compounds, reducing the cost of the treatment.
- Carbon nanotubes are being developed to clean up oil spills. Researchers have found that adding boron atoms during the growth of carbon nanotubes causes the nanotubes to grow in a sponge like material that can absorb many times its weight in oil.

9. Nano technology to improve batteries

- Reducing the possibility of batteries catching fire by providing less flammable electrode material.

- Increasing the available power from a battery and decreasing the time required to recharge a battery by coating the surface of an electrode with nanoparticles.
- Increasing the shelf life of a battery by using nanomaterials to separate liquids in the battery from the solid electrodes when there is no draw on the battery. This separation prevents the low level discharge that occurs in a conventional battery, which increases the shelf life of the battery dramatically.
- Use of silicon nanoparticles based anodes can increase the capacity of Li-ion batteries by up to 10 times.
- Ultracapacitor using single atom thick graphene sheets to store electrical charge.

More uses of Nano-Technology

- **CLOTHES THAT CLEAN THEMSELVES**
  - A group of researchers located in Australia at Monash University in Victoria are developing a process that could lead to self cleaning wool and silk. They have found a way to coat fibers with titanium dioxide nano-crystals, which break down food and dirt in sunlight.
- **PHOTOLITHOGRAPHY AND NANOLITHOGRAPHY**
  - Photolithography is a process used in micro fabrication which is the removal of thin films selectively (or the bulk of a substrate), by utilizing a light to transfer a geometric pattern from a photo mask to a light-sensitive chemical on the substrate. To develop modern microprocessors, manufacturers use 'photolithography', the highest technology in the nano-scale dimension of printing technology. Photolithography has been a perfect way to produce massively integrated circuits and computer chips.
- NANOMATERIALS
  - The nanomaterials field includes subfields which develop or study materials having unique properties arising from their nanoscale dimensions. Nanomaterials are made possible by manipulating matter at nanoscale (less than 100 nanometers, or approximately molecular scale). At nanoscale, ordinary substances like carbon and clay take on surprising properties – including greater reactivity, unusual electrical properties, and enormous strength per unit of weight – that can enable the creation of new types of medicine, solar cells, water desalination and filtration, super-slick coatings, and stronger composites. Invisible to the naked eye, nanomaterials have already found their way into products as varied as pharmaceuticals, sunscreens, bacteria-killing socks, and composite bicycle frames. And recent generations of semiconductors have features in the tens of nanometers, in effect making them nanotechnology. Research has given rise to many materials which may be useful in nanotechnology, such as carbon nanotubes and other fullerenes, and various nanoparticles and nanorods.
- **NANOROBOTICS**
  - It is the technology of creating robots or nanomachines at the microscopic scale

of nanometres (10-9 meters) or at least very close of this scale. The nanorobots are also named 'nanobots', 'nanoids' or 'nanites'. Scientists have been developing these robots to carry out many important functions in different professional fields such as medicine, engineering, manufacturing and many others even though non- biological nanorobots are yet to be created.

- **OPTICAL USES**
  - Advances have been made to produce the first anti-reflective ultrathin polymer sunglasses. In optical surgery, nano-optics increases the precision of pupil repair and other type of surgery using laser technology.

NANOTOXICOLOGY

Nanotoxicology is the study of the toxicity of nanomaterials. Because of quantum size effects and large surface area to volume ratio, nanomaterials have unique properties compared with their larger counterparts. Nanotoxicology is a branch of bionanoscience which deals with the study and application of toxicity of nanomaterials. Nanomaterials, even when made of inert elements like gold, become highly active at nanometre dimensions. Nanotoxicological studies are intended to determine whether and to what extent these properties may pose a threat to the environment and to human beings. For instance, Diesel nanoparticles have been found to damage the cardiovascular system in a mouse model.

NANOPOLLUTION

Nanopollution is a generic name for all waste generated by nanodevices or during the nanomaterials manufacturing process. This kind of waste may be very dangerous because of its size. It can float in the air and might easily penetrate animal and plant cells causing unknown effects. Most human-made nanoparticles do not appear in nature, so living organisms may not have appropriate means to deal with nanowaste. It is probably one great challenge to nanotechnology: how to deal with its nanopollutants and nanowaste.

THE SAFETY, HAZARDS AND PUBLIC ISSUES WITH NANOTECHNOLOGY

There are some argumentations relating to think of the social impact of nanotechnology as a 'technological tsunami' an enormous impact that will change dramatically the fabric of society. People dealing with the ethical aspects of nanotechnology argue that such transformative technology could exacerbate the division of rich and poor known as 'nano-divide'.

The critics of nanotechnology point to the potential toxicity of new classes of nano substances that adversely affect the stability of cell membranes or disturb the immune system when inhaled or digested. The Titanium Oxide nanoparticle used in sunscreen can get into human food chain, which causes quicker aging of colon cells. The Cadmium Selenide nanoparticles, also called quantum dots, can cause cadmium poisoning in humans.

The **Centre for Responsible Nanotechnology** warns of the broad societal implications of untraceable weapons of mass destruction, networked cameras for use by the government, and weapons developments fast enough to destabilize arms races.

Another area of concern is the effect that industrial-scale manufacturing and use of nanomaterials would have on human health and the environment, as suggested by nanotoxicology research. For these reasons, groups such as the Centre for Responsible Nanotechnology advocate that nanotechnology be regulated by governments. Others counter that overregulation would stifle scientific research and the development of beneficial innovations.

Some nanoparticle products may have unintended consequences. Researchers have discovered that bacteriostatic silver nanoparticles used in socks to reduce foot odour are being released in the wash. These particles are then flushed into the waste water stream and may destroy bacteria which are critical components of natural ecosystems, farms, and waste treatment processes.

In general, smaller particles are more bioactive and toxic. Their ability to interact with other living systems increases because they easily get into the body, and there may be further biochemical reactions like creation of free radicals that damage cells. There is no doubt that nano-particles have interesting and useful properties strong economic drives and competition in the market place may be taking precedence over methodical scientific prudence when it comes to public health and possible dangers of nano technology.

NANOTECHNOLOGY RESEARCH IN INDIA

A vision group under the leadership of Prof. CNR Rao was formed and entrusted with the task of formulating a National Nanotechnology Policy. Under this $ 250 million has been allocated for R&D in Nanotechnology. Two centres of excellence i.e. Institute of Nanoscience and Nanotechnology have been proposed to be built in Mumbai and Bangalore. Sabeer Bhatia, co-founder of Hotmail has proposed to build a nano-city in Chandigarh.

NANO SCIENCE AND TECHNOLOGY INITIATIVE (NSTI)

Nanoscience and technology is receiving increasing attention all over the world. The Department of Science and Technology of Government of India has assessed the importance of this highly emerging inter-disciplinary field and launched a national programme titled Nano-science and Technology Initiative" (NSTI). The programme focused at overall research and development in nano science and technology with vigour so that India can become a significant player in the area and contribute to the development of new technologies besides carrying out basic research.

Under this initiative, close to 100 research projects on the synthesis and assembly of ceramic nanoparticles, nanotubes, nanowires, nanoporens, solids, nanostructured alloys and DNA Chips have been supported. An impressive array of instruments has also been put in place of facilitate characterisation of the synthesised materials. On the application side, projects on nanolithography, nanostructured high strength materials, targeted drug delivery systems, DNA chips etc., have been supported. Mine Centre of excellence have been established in different regions of the country.

The Department of Information Technology has started Nanotechnology Development Programme to create infrastructure for research in nanoelectronics and nano-meteorology at National level and also to fund small and nano devices, carbon nano ties (CNT) nano systems etc. The Department has initiated a major project for setting up of nano-electronics centres at IISC, Bangalore and IIT, Bombay.

INTERNATIONAL CENTER FOR TECHNOLOGY ASSESSMENT (ICTA)

ICTA is a U.S. non-profit bi-partisan organization, based in Washington, D.C. ICTA aims to provide the public with full assessments and analyses of technological impacts on society. ICTA explores the economic, ethical, social, environmental and political impacts that can result from the applications of technology or technological systems.

ICTA seeks to assist the public and policy makers in better understanding how technology affects society. ICTA works towards adequate oversight of nanotechnology through its Nanotechnology Project NanoAction. The implications of nanotechnology run the gamut from the medical, ethical, mental, legal and environmental applications, to fields such as engineering, biology, chemistry, computing, materials science, military applications, and communications.

CHAPTER – 10

LATEST ADVANCEMENTS IN TECHNOLOGY

I. BIG DATA

Big Data can be described as a set of electronic data so complex and large in volume that it is very difficult to manage it using traditional basic data management tools. The term is also often use to describe large and complex data sets along with the ability to process and analyze it. Big data should not be defined as "big" based on the size of the data alone. It is a phenomenon that is a result of the rapid acceleration and exponential growth in the volume of high velocity, complex and diverse types of data, requiring new architecture, techniques, algorithms, and analytics to manage it and extract value and hidden knowledge from it. For example, real-time location feeds from millions of cellphones, tracking how social media is responding to a new product etc. The three characteristics of big data are:

- **Volume:** Organizations collect data from a variety of sources, including business transactions, social media and information from sensor or machine-to-machine data. In the past, storing it would've been a problem – but new technologies (such as Hadoop) have eased the burden.
- **Velocity:** Data streams in at an unprecedented speed and must be dealt with in a timely manner. RFID tags, sensors and smart metering are driving the need to deal with torrents of data in near-real time.
- **Variety:** Data comes in all types of formats – from structured, numeric data in traditional databases to unstructured text documents, email, video, audio, stock ticker data and financial transactions.
- **Veracity (uncertainty and incompleteness):** Data flows can be highly inconsistent with periodic peaks. For example, if something starts to trend on social media. Data also comes from multiple sources, which makes it difficult to link, match, cleanse and transform data across systems.

The increasing volume and detail of information captured by enterprises, the rise of multimedia, social media, and the Internet of Things will fuel exponential growth in data for the foreseeable future.

Generally, most organizations have several goals for adopting big data projects. While the primary goal for most organizations is to enhance customer experience, other goals include cost reduction, better targeted marketing and making existing processes more efficient. As organizations create and store more transactional data in digital form, they can analyze their performance on all parameters. Sophisticated analytics can substantially improve decision-making. Big data allows ever-narrower segmentation of customers and therefore much more precisely tailored products or services. Big data can be used to improve the development of the next generation of products and services.

WHO USES BIG DATA?

Big data affects organizations across practically every industry. Some examples include:

Banking: With large amounts of information streaming in from countless sources, banks are faced with finding new and innovative ways to manage big data. Big data helps banks understand customers and boost their satisfaction, while also minimizing risk and fraud.

Education: Educators armed with data-driven insight can make a significant impact on school systems, students and curriculums. By analyzing big data, they can identify at-risk students, make sure students are making adequate progress, and can implement a better system for evaluation and support of teachers and principals.

Manufacturing: Armed with insight that big data can provide, manufacturers can boost quality and output while minimizing waste. For instance, car manufacturers are using data obtained from sensors embedded in cars to create innovative after-sales service offerings such as proactive maintenance and also make improvements in next models.

Retail: Customer relationship building is critical to the retail industry – and the best way to manage that is to manage big data. Retailers need to know the best way to market to customers, the most effective way to handle transactions, and the most strategic way to bring back lapsed business. Big data remains at the heart of all those things.

Governments: Governments across the world are using big data for traffic management, fraud detection, managing utilities, financial market analysis, health care, education, fighting crime, environment protection etc.

- Singapore's Land Transport Authority regularly crunches 20 million fare transactions per day to better understand the transport needs of its citizens. Based on the extensive usage data, it has been able to build more cost effective routes for cars, buses and trains, schedule the best timings and lowest fares. The remarkable aspect is that while doing so, it has also been able to reduce the cost of its revenue collection.
- The federal labour agency in Germany) not only improved its customer services but also saved billion in costs using big data strategies.
- The US Food and Drug Administration (FDA) is deploying big data technologies across many labs involved in testing to study patterns of foodborne illness.
- The US National Center for Atmospheric Research has developed a big data strategy to integrate research and data from utility companies, universities, and industry to create better weather forecasts and predict supply and demand for power.

INDIAN GOVERNMENT AND BIG DATA:

Indian government is looking at ways to bring data analytics, supercomputing and the Aadhaar database together so as to design better public policies. Some field where it can be helpful are given below:

TAX EVASION:

The government of India has shown emphasised focus on increasing tax base and tackling black money through policy interventions like demonetisation, GST roll out, tax agreements, Benami Property Act, etc. These initiatives will allow the revenue departments to develop a data supply chain i.e.capture and store data at an unprecedented scale, and speed. This data can be supplemented with data generated through digital transactions, JAM (Jan Dhan, Aadhaar & Mobile) trinity, and data from across industries. However, having this data alone will not help unless there is a focussed approach towards making this data intelligent and generate insights.With skills and manpower constraints across tax departments, the challenge will remain in identifying tax evasion andor fraudulent behavior non-intrusively.

Big data can play a critical role in integrating and exploiting the multiple data sources to help tax departments in efficient discharge of their responsibilities and bridging the tax gap. The data integration and matching of the PAN based demonetisation information with that of I-T databases such as tax returns, TDS, third-party reporting, tax payments, would be used to build a comprehensive profile for the taxpayer. The income tax (I-T) department can use Big Data analytics to track down tax evaders by collecting information such as common address, mobile number and e-mail to establish relationship between their multiple PANs. It can also help identify tax malpractices like circular trading, hawala dealing, input tax credit (ITC) over-claims, sales under-declarations, transfer pricing manipulations, etc.

HEALTH CARE:

Data analytics allows you to record disease outbreaks and analyse disease patterns and seasonlaity thereby improving public health care and drug supplies. Researching large amount of data helps to determine needs, predict and prevent future crisis and offer required services. Big Data Analytics is a very strong tool that helps to monitor records and analyse claim requests to curtail down fraud cases. Big Data Analytics can be used to analyse large amount of data produced by the hospitals in real-time. This can help healthcare organizations in safety monitoring and also identify gaps. Electronic Health Records can be evaluated using data analytics approach to predict risks posing patients and provide them effective care.

AGRICULTURE:

Big data can provide agri-business with greater visibility into supplier quality levels, and greater accuracy in predicting supplier performance over time. In India, every year 21 million tons of wheat is lost, primarily due to scare cold-storage centres and refrigerated vehicles, poor transportation facilities and unreliable electricity supply. Big Data has the potential of systematisation of demand forecasting thus reducing such losses. Proliferation of data offers unprecedented opportunities to understand consumer needs and preferences of farmers, and to deliver tailored services and products for organisations that can make sense of this data. In many countries, Big Data and advanced analytics are streamlining food processing value chains. Big Data is also being used for optimising production schedules based on supplier, customer, machine availability and cost constraints.

CONCERNS:

Several issues will have to be addressed to capture the full potential of big data. Policies related to privacy, security, intellectual property, and even liability will need to be addressed in a big data world. It incentivizes more collection of data and longer retention of it. Most people are not aware of how much information is being collected.

Many customers may feel uncomfortable with the idea that businesses are able to collect such detailed information about their identities, behaviors, motivations, and other sensitive facts. Many organisations don't have encryption, policy enablement, compliance, risk management, and other security features built in.

DEPARTMENT OF SCIENCE AND TECHNOLOGY'S LAUNCHED BIG DATA INITIATIVE (BDI):

- To promote and foster Big Data Science, Technology and Applications in the country and to develop core tools for wider applications in Govt.
- To understand the present status of the industry in terms of market size, different players providing services across sectors/ functions, opportunities, SWOT of industry, policy framework (if any), present skill levels available etc.
- To carryout market landscape survey to assess the future opportunities and demand for skill levels in next 10 years
- To evolve a strategic Road Map and micro level action plan clearly defining of roles of various stakeholders – Govt., Industry, Academia, Industry Associations and others with clear timelines and outcome for the next 10 years.

II. INTERNET OF THINGS

Increasingly, the connected world includes physical objects. Machinery, shipments, infrastructure, and devices are being equipped with networked sensors and actuators that enable them to monitor their environment, report their status, receive instructions, and even take action based on the information they receive. Even people can be equipped with sensor-enabled devices—to track their health status, for example. More than ten billion devices around the world are currently connected to the Internet, including computers and smartphones. That number is expected to increase dramatically within the next decade.

The Internet of Things refers to the use of sensors, actuators, and data communications technology built into physical objects—from roadways to pacemakers—that enable those objects to be tracked, coordinated, or controlled across a data network or the Internet. There are three steps in Internet of Things applications: capturing data from the object, aggregating that information across a data network, and acting on that information—taking immediate action or collecting data over time to design process improvements.

Internet of Things technology ranges from simple identification tags to complex sensors and actuators. RFID tags can be attached to almost any object. Sophisticated multisensor devices and actuators that communicate data regarding location, performance, environment, and condition are becoming more common. With newer technologies such as micro electromechanical systems (MEMS), it is becoming possible to place very sophisticated sensors in virtually any object (and even in people). The Internet of Things can be used to create value in several ways. In addition to improving productivity in current operations, the Internet of Things can enable new types of products and services. The widespread adoption of the Internet of Things will take time, but that timeline is shrinking thanks to improvements in underlying technologies such as

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miniature sensors and wireless networks.

HOW WILL THE IOT AFFECT BUSINESS AND WORK?

This all depends on your industry:

- Manufacturing is perhaps the furthest ahead in terms of IoT, as it's useful for organising tools, machines and people, and tracking where they are. By monitoring machinery in real time, companies can better control the flow of goods through factories and avoid disruptions by taking immediate action or engaging in preventive maintenance when problems arise. Machines with embedded actuators in addition to sensors can be programmed to take action on their own.
- In the energy industry, sensors are used to map unexplored fossil fuel fields to pinpoint deposit locations.
- Remote monitoring, for example, has the potential to make a huge difference in the lives of people with chronic diseases while simultaneously attacking a significant source of rising health-care costs.
- Counterfeit drugs are another health-care problem with a possible Internet of Things solution. Currently, more than $75 billion worth of counterfeit drugs are sold per year, and that amount is growing by around 20 percent annually.55 Using sensors on bottles and packages could reduce the sale of counterfeit drugs by enabling consumers to ensure that their medications are legitimate.
- Farmers have also been turning to connected sensors to monitor both crops and cattle. Soil sensors can track changes in soil moisture, carbon, nitrogen, and soil temperature. Such data would help farmers optimize irrigation schedules, avoiding crop damage.

The examples are endless, and all we can predict is that connected devices will likely creep into most businesses, just the way computers and the web have.

SMART CITIES:

IoT is more than smart homes and connected appliances, however. IoT will be instrumental in the planning of smart cities, and not just for communication networks but also for sanitation, transportation, healthcare, energy use and many more. Companies are working towards building network infrastructure in the planned smart cities in India to enable IoT technologies with the aim of linking intelligence and information with devices. The ability to monitor and control power grids and water systems could have major impacts on energy conservation, greenhouse gas emissions, and water loss.

The Internet of Things is an important enabler of better management of urban infrastructure, systems, and services, including traffic, waste and water systems, and public safety. Sensors that monitor traffic patterns can generate the data to optimize flow by adjusting traffic light timing, imposing congestion charges, and changing bus routes, for example. Sensors can automatically trigger an alert to divert traffic around accidents to minimize costly delays. By using sensors to gather information to streamline operations, public-sector functions such as garbage collection and waste management can become much more productive. Sensor data could also be used to improve policing. Magnetic sensors in roads can count vehicles passing by, enabling real-time adjustments in traffic signal timing.

CONCERNS:

Security and privacy are the biggest challenges for IoT. All these devices and systems collect a lot of personal data about people – that smart meter knows when you're home and what electronics you use when you're there – and it's shared with other devices and held in databases by companies. The connections that allow remote machines to take action are subject to hacking by criminals or terrorists. The data collected via health monitoring could be abused. Even the in-home controllers for some smart grid applications raise questions about privacy and autonomy. These issues will need to be addressed before society and businesses will be able to enjoy the full benefits of the Internet of Things.

POLICIES:

For policy makers, the Internet of Things also brings great opportunities and challenges. As operators of infrastructure and public services (often including health care), governments could be major adopters of Internet of Things applications. Governments will need to establish clear understandings of the privacy risks that accompany the Internet of Things. Unfortunately, computer systems and networks could be the targets of criminals and terrorists. Policy makers faced with these issues will need to think comprehensively and globally. They will need to build consensus regarding what protections to put in place and work across borders and levels of government to make sure these protections can and will be universally enforced.

III. SMALL SATELLITES

What are SmallSats?

The size and cost of spacecraft vary depending on the application; some you can hold in your hand while others like Hubble are as big as a school bus. Small spacecraft (SmallSats) focus on spacecraft with a mass less than 180 kilograms and about the size of a large kitchen fridge. Even with small spacecraft, there is a large variety of size and mass that can be differentiated.

- Minisatellite, 100-180 kilograms
- Microsatellite, 10-100 kilograms
- Nanosatellite, 1-10 kilograms
- Picosatellite, 0.01-1 kilograms
- Femtosatellite, 0.001-0.01 kilograms

What are CubeSats?

CubeSats are a class of nanosatellites that use a standard size and form factor. The standard CubeSat size uses a "one unit" or "1U" measuring 10x10x10 cms and is extendable to larger sizes; 1.5, 2, 3, 6, and even 12U. Originally developed in 1999 by California Polytechnic State University at San Luis Obispo (Cal Poly) and Stanford University to provide a platform for education and space exploration.

ISRO Nano Satellite (INS):

PSLV-C37, which created a record in February, 2017 by putting 104 satellites in orbit, also carried two ISRO Nano Satellites – INS-1A and INS-1B. ISRO Nano Satellite (INS) is a versatile and modular Nano satellite bus system envisioned for future science and experimental payloads. The INS system is developed as a co-passenger satellite to accompany bigger satellites on PSLV. The primary objectives of INS system are to:

- Design and develop a low cost modular Nano satellite in the weight range of 10 kg capable of carrying payloads up to a weight of 5 kg
- Provide an opportunity for ISRO technology demonstration payloads
- Provide a standard bus for launch on demand services
- Provide an opportunity to carry innovative payloads for Universities/R&D laboratories

ADVANTAGES:

Makes space more accessible:

New technologies enable a CubeSat to perform many of the functions of a satellite a hundred times heavier and much larger, but at substantially less cost. The development of CubeSats has advanced into it's own industry with government, industry and academia collaborating for ever increasing capabilities. CubeSats now provide a cost effective platform for science investigations, new technology demonstrations and advanced mission concepts using constellations, swarms disaggregated systems. Low cost and a tolerance of less-stringent standards allow multiple nanosats to be built faster. This allows for a higher risk of failure. Nanosats have a relatively short life, which might be no more than a year or two in low-Earth orbit before re-entering the atmosphere and burning up.

Decentralisation:

CubeSats allow operations to be decentralised. In place of a single large satellite, multiple smaller satellites can be used. The major advantage of this is reliability. If a technical failure or debris in space takes out any component of a satellite, the whole satellite is rendered useless. This is exactly what happened to India's first lunar probe Chandrayaan-1, where ISRO lost all contact to the satellite 310 days after it had been in orbit.

Uninterrupted coverage:

We currently use satellites of every size for broadcasting media, tracking the weather, and navigating the world via GPS. But there are data gaps for conventional satellites, which are powerful but have limited coverage areas. Flocks of small satellites can provide data from a larger coverage area more quickly. For example, conventional satellites have coverage gaps that leave shipping companies and their customers in the dark for large stretches of transport time, but a CubeSat network can track vessels practically in real-time, no matter where they are. CubeSats promise is uninterrupted, 24-hour geospatial data. That can help countries track dangerous weather systems, help commercial actors protect their investments, and assist nation-states with monitoring threats.

Innovations:

A company Planet Labs is putting a series of more than 100 CubeSats in space. These Earth-imaging satellites will provide imagery to a variety of users as they focus on highly populated and agricultural areas to study urbanization and deforestation. The images will be used to improve natural disaster relief and crop yields in developing nations. Last year the world's first "phonesat" went into orbit. It was a Google Nexus One smartphone incorporated into a three-unit CubeSat called STRaND-1. The idea was to test the components of the smartphone in a space environment. The phone was loaded with a number of experimental apps for such things as taking photographs and recording magnetic fields during orbit.

Democratization of atmospheric and space research:

Until recently the idea of launching a satellite into space was an expensive business and the preserve of governments, international space organisations and multi-million dollar companies. But now, Nanosats are being built at far less expense and launched by university researchers and start-up companies. Thus, Nanosats have the potential to democratize atmospheric and space research. And as rocket companies bring down their per-pound launch costs, CubeSat market grow big.

India:

India has ample potential in the area of CubeSat development. With a large student base, especially engineers, we can easily start research and development into this. Since India already has a successful space programme, it should not shy away from initiating a programme of this sort. Universities need to start competitions for design, and the Department of Space should incentivise the process.

LIMITATIONS:

Nanosats also face two other limiting factors: communications and propulsion. Those used for academic work principally rely on amateur-radio frequencies, with basic equipment squeezed into the CubeSat form. Transmission and reception are further hindered by the size of antennae or dishes, both on the ground and on the satellites. More development in communications equipment and investment in ground stations would improve things.

The other bugbear, propulsion, is harder to solve. However, engineers will soon design tiny spaceship engines using safer fuel. Even a basic capability to push in one direction would allow nanosats to remain in orbit longer, or allow a satellite that has been placed into low-Earth orbit, using an inexpensive launch provider, to nudge itself to a higher geostationary orbit.

CONCERNS:

While nanosats are much smaller than the average low earth orbiting satellite, there will eventually be many of them. They are still large enough to cause serious damage to other spacecraft supplying important services such as Earth observation and meteorology. The cost of insurance to cover the potential third party liability damage is a significant entry barrier for many nanosat builders. Many Governments are now faced with trying to regulate for the challenges and opportunities that small satellites present.

IV. AUGMENTED REALITY AND VIRTUAL REALITY

What is Virtual Reality?

Virtual reality (VR) is an artificial, computer-generated simulation or recreation of a real life environment or situation. It immerses the user by making them feel like they are experiencing the simulated reality firsthand, primarily by stimulating their vision and hearing. VR is typically achieved by wearing a headset like Facebook's Oculus equipped with the technology, and is used prominently in two different ways:

- To create and enhance an imaginary reality for gaming, entertainment, and play (Such as video and computer games, or 3D movies, head mounted display).
- To enhance training for real life environments by creating a simulation of reality where people can practice beforehand (Such as flight simulators for pilots).

What is Augmented Reality?

Augmented reality (AR) is a technology that layers computer-generated enhancements atop an existing reality in order to make it more meaningful through the ability to interact with it. AR is developed into apps and used on mobile devices to blend digital components into the real world in such a way that they enhance one another, but can also be told apart easily. AR technology is quickly coming into the mainstream. It is used to display score overlays on telecasted sports games and pop out 3D emails, photos or text messages on mobile devices. Leaders of the tech industry are also using AR to do amazing and revolutionary things with holograms and motion activated commands.

Augmented Reality vs. Virtual Reality

Augmented reality and virtual reality are inverse reflections of one in another with what each technology seeks to accomplish. Virtual reality offers a digital recreation of a real life setting, while augmented reality delivers virtual elements as an overlay to the real world. Both technologies enable experiences that are becoming more commonly expected and sought after for entertainment purposes.

How do Augmented and Virtual Realities Differ?

Augmented reality enhances experiences by adding virtual components such as digital images, graphics, or sensations as a new layer of interaction with the real world. Contrastingly, virtual reality creates its own reality that is completely computer generated and driven. Virtual Reality is usually delivered to the user through a head-mounted, or hand-held controller. This equipment connects people to the virtual reality, and allows them to control and navigate their actions in an environment meant to simulate the real world. Augmented reality is being used more and more in mobile devices such as laptops, smart phones, and tablets to change how the real world and digital images, graphics intersect and interact.

Virtual reality and augmented reality are great examples of experiences and interactions fueled by the desire to become immersed in a simulated land for entertainment and play, or to add a new dimension of interaction between digital devices and the real world. Alone or blended together, they are undoubtedly opening up worlds-both real and virtual alike.

AUGMENTED REALITY:

Augmented reality, or AR, has been called the next big paradigm shift in computing. Global technology leaders, including Google, Microsoft, Facebook, Snapchat and Apple, have all staked significant claims in the AR "digital" land rush. The increasing availability of broadband internet along with the rise of the long awaited internet of things (IoT) have helped to accelerate the roll-out of smart and connected infrastructure across cities, regions and entire countries. This smart infrastructure and the massive amount of real-time, geo-specific data it generates provides both the engine and the fuel for AR in the public sector.

Augmented reality technologies:

Over the past few years, the core AR software and, most important, the devices that will deliver the augmented reality experiences, have finally begun to mature. They include:

- Handhelds and mobile devices, primarily smartphones and tablets, and built-for-purpose mobile workforce devices
- Head-up displays (HUDs) for windshields, screens, visors
- Head mounted displays (HMDs)
- Glasses, goggles, visors and helmets
- Contact lenses, virtual retina displays
- Spatial displays

AUGMENTED REALITY USES IN PUBLIC SECTOR:

There are myriad uses for AR in the broad public sector, and as with any new technological innovation, its potential is limited only by the creativity and ingenuity of its users. The following are potential use cases that provide a overview of the possibilities.

1. **E-governance:** Citizen engagement and e-services: Government forms and applications can be accessed, viewed and completed through a variety of AR devices – smartphones, smart glasses, in-office displays and readers – with a full range of accessibility aids (sound, language translations, visual and graphic instructions, etc.). citizens and businesses can actually "see" through augmented reality what planned public works projects will actually look like – highways, water, and energy facilities, public parks etc.
2. **Asset management and maintenance:** Municipal workforces can efficiently maintain city assets – from streetlights, cell towers and fire hydrants, roads – using head-up windshield displays on maintenance vehicles, smart goggles etc. Experts, specialists and supervisors can provide real-time guidance and technical expertise to field workers with remote AR connections.
3. **Public safety and emergency services:** Firefighter and disaster first responders being able to navigate to and through their environments with emergency vehicles equipped with AR head-up windshield displays providing route guidance and real-time sensor data on environmental and hazardous conditions; and with helmet-mounted AR devices and visors allowing them to see and hear through smoke, fire,

rubble, poor weather and other conditions. AR disaster applications can provide visual and audio guidance for citizens seeking refuge, evacuation routes, or emergency assistance in a disaster situation. Imagine real-time data-driven AR applications that allow law enforcement officers to access location specific information and data on dangerous situations via smart glasses, in-vehicle displays etc.

4. **Public health, wellness and sustainability:** Inspectors of all kinds – health, building and public safety, environmental quality, etc. – can instantaneously "see" and interact with all the available data and information related to a facility, an agricultural area, a neighbourhood or district.
5. **Transportation and urban mobility:** Operators of rolling stock – trains, buses, shuttles, car/vanpools – will have AR windshield displays providing real-time information such as traffic incidents, scheduling and route changes, customer needs, vehicle maintenance and health, etc. Physical maps of transit systems can be augmented so that users can visually and or audibly access the portion of the transit network that they actually use and need.
6. **Culture, heritage and tourism:** Across the globe, protection of heritage and culture is a high priority. One of the richest uses of AR is to enhance places, such as historic buildings, castles, monuments and heritage sites and battlefields. Museums and culturally significant buildings are perfect candidates for AR information and rich content around artwork, artefacts, publications, etc. Natural resources – including national parks, coastlines, forest and wetlands – combined with AR can provide a powerful educational experience while simultaneously encouraging and monitoring the appropriate use and preservation of natural resources.

The effectiveness and viability of AR technology depends on an organisation's data and technology infrastructure. For example, real-time data visualization on AR-equipped smarphones, tablets or goggles is only possible with the necessary analytical capabilities and data. Furthermore, most AR devices rely on some means of connecting to data in a timely manner, making access to wireless networks a prerequisite. Privacy, security, health risks are the primary concerns.

V. 3D PRINTING

3D printing belongs to a class of techniques known as additive manufacturing. Additive processes build objects layer-by-layer rather than through molding or subtractive techniques (such as machining). Today, 3D printing can create objects from a variety of materials, including plastic, metal, ceramics, glass, paper, and even living cells. These materials can come in the form of powders, filaments, liquids, or sheets.

TECHNIQUES:

A variety of 3D printing techniques are in use today. In all cases, objects are formed one layer at a time, each layer on top of the previous, until the final object is complete. With some techniques this is accomplished by melting material and depositing it in layers, while other techniques solidify material in each layer using lasers. Major techniques include

- **Selective laser sintering (SLS):** In this technique, a layer of powder is deposited on the build platform, and then a laser "draws" a single layer of the object into the powder, fusing the powder together in the right shape. It is capable of producing very complex parts.
- **Direct metal laser sintering (DMLS):** It is similar to selective laser sintering but deposits completely melted metal powder free of binder or fluxing agent, thus building a part with all of the desirable properties of the original metal material. DMLS is used for rapid tooling development, medical implants etc.
- **Fused deposition modeling:** A filament of plastic resin, wax, or another material is extruded through a heated nozzle in a process in which each layer of the part is traced on top of the previous layer.
- **Stereolithography:** A laser or other UV light source is aimed onto the surface of a pool of photopolymer (light-sensitive resin). The laser draws a single layer on the liquid surface; the build platform then moves down, and more fluid is released to draw the next layer. SLA is widely used for rapid prototyping and for creating intricate shapes with high-quality finishes, such as jewelry.
- **Inkjet bioprinting:** Bioprinting uses a technique similar to that of inkjet printers, in which a precisely positioned nozzle deposits one tiny dot of ink at a time to form shapes. In the case of bioprinting, the material used is human cells rather than ink. The object is built by spraying a combination of scaffolding material (such as sugar-based hydrogel) and living cells grown from a patient's own tissues. After printing, the tissue is placed in a chamber with the right temperature and oxygen conditions to facilitate cell growth. When the cells have combined, the scaffolding material is removed and the tissue is ready to be transplanted.

Advantages:

3D printing has several advantages over conventional construction methods. With 3D printing, an idea can go directly from a file on a designer's computer to a finished part or product, potentially skipping many traditional manufacturing steps, including procurement of individual parts, creation of parts using molds, machining to carve parts from blocks of material, welding metal parts together, and assembly. 3D printing can also reduce the amount of material wasted in manufacturing and create objects that are difficult or impossible to produce with traditional techniques, including objects with complex internal structures that add strength, reduce weight, or increase functionality. Bioprinting can create organs with an internal network of blood vessels.

Limitations:

Current limitations of 3D printing, which vary by printing technique, include relatively slow build speed, limited object size, limited object detail or resolution, high materials cost, and, in some cases, limited object strength. However, in recent years rapid progress has been made in reducing these limitations.

Increasing usage:

3D printers are already commonplace for designers, engineers, and architects, who use them to create product designs and prototypes. 3D printing is also gaining traction for direct production of tools, molds, and even final products. These newer uses of 3D printing could enable unprecedented levels of mass customization, shrinking and less-costly supply chains, and even the "democratization" of manufacturing as consumers and entrepreneurs begin to print their own products. Looking longer term, perhaps beyond 2025, one category of 3D printing – bioprinting of living organs – has long-term potential to save or extend many lives.

Applications:

3D printing for producing complex, low volume, and highly customizable products is already accelerating. Boeing prints more than 200 different parts for ten aircraft platforms. In health care, manufacturers have been offering printed custom hearing aid earpieces. The dental appliance makers are making appliances per day using stereolithography printers. Entrepreneurs are also designing and selling 3D-printed products, such as iPhone cases, that allow designers to upload designs that the company then prints and ships to consumers.

Will take time to expand:

In recent years, 3D printing has attracted increasing attention. Some enthusiasts even proclaim that 3D printing will bring "the next industrial revolution." Other observers have reacted with skepticism and point to the technology's current limitations and relatively low level of adoption. While 3D printing does have the potential for disruptive impact on how products are designed, built, distributed, and sold, it could take years before that impact is felt beyond a limited range of goods. Nonetheless, rapidly improving technology and a variety of possible delivery channels for 3D-printed goods (such as using the local print shop) could ultimately result in many products being 3D-printed. In fact, personal 3D printers are already becoming available for less than $1,000.

Huge potential:

As 3D printing continues to mature and grow, it has the potential to address many important needs. In intensely competitive consumer products markets, 3D printing can meet rising expectations for quality design and personalization, including better fit for items such as shoes or helmets. 3D printing also has the potential to address concerns about the waste and environmental impact of traditional manufacturing processes and supply chains. Improvements in speed and performance and falling costs will likely accelerate the spread of 3D printing. At least for the next two decades, traditional manufacturing techniques will almost certainly have a large cost advantage over additive manufacturing for most high-volume products. However, 3D printing could become an increasingly common approach for highly complex, low-volume, highly customizable parts.

WAY AHEAD:

While the range of products that consumers and companies choose to 3D print could be limited at first, the ability to easily design and self-manufacture products could create significant consumer surplus and even influence consumer culture. Access to 3D printers is already inspiring a "maker" subculture in which enthusiasts share designs and ideas. 3D printing could eventually spawn the same kind of dynamic, complex ecosystem that exists in software and Web development – in which developers can easily share and collaborate with one another – extending this kind of innovation ecosystem to the creation of physical objects. Budding product designers and entrepreneurs can use 3D printing to quickly reach a mass, even global, audience.

OPPORTUNITIES AND CHALLENGES FOR POLICY MAKERS:

3D printing poses opportunities as well as challenges for policy makers in both advanced and developing economies. Societies can benefit from products that are made with less waste that do not require transport over great distances and, therefore, have less impact on the environment. Policy makers should consider supporting the development of 3D printing, in particular by funding research in 3D printing technologies. The challenges for policy makers include addressing regulatory issues – such as approving new materials for use – ensuring appropriate intellectual property protections, and assigning legal liability for problems and accidents caused by 3D-printed products. Governments will also be called upon to clarify how intellectual property rights will be protected. 3D printers have already been used to make handguns, raising another set of issues. Policy makers face the challenge of evaluating and addressing these risks without stifling innovation or limiting the value that this technology can provide.

VI. HYPERLOOP

What is a hyperloop?

It is a system where magnetically levitating capsules/pods are sent at high speeds through low-pressure tubes. Pods carrying passengers would travel through the tubes at speeds topping out over 700 mph (1100 kmph). The technology is expected reduce the transport time, of goods and people, by more than 80%. It was entrepreneur Elon Musk who came up with the idea for a hyperloop. The system is now being developed to connect Abu Dhabi and Dubai.

Hyperloop in India:

Hyperloop One has announced its intentions to begin operations in India by 2021. There are reports that the company has already begun talks with the Indian government to see how to make this possible and to combine this with the Make in India mission by sourcing the necessary material locally. The government has referred the proposal to set up a hyperloop transportation system in the country to NITI Aayog. Hyperloop One, the company developing the technology, has begun an online vote for people to suggest and choose the best route to deploy a hyperloop in their countries. The route choices for India are: Bengaluru-to-Chennai (334 km in 20 minutes), Bengaluru- to-Thiruvananthapuram (736 km in 41 minutes), Delhi-to-Mumbai via Jaipur and Indore (1,317 km in 55 minutes), Mumbai-to-Chennai via Bengaluru (1,102 km in 50 minutes), and Bengaluru to Chennai (334 km in 20 minutes).

Pros and Cons:

If approved, such plans would enable India to jump forward in its transport infrastructure and could revolutionise the way business is conducted. In a country like India where railway infrastructure is abysmal and the airline industry is priced beyond the abilities of most of the populace, it is doubtful if India can really afford another expensive transport system. However, Hyperloop makers say that the cost per kilometre will be lower than that of bullet trains.

CHAPTER – 11

RECENT DEVELOPMENTS IN OUTER SPACE

1. BLAZARS

- NASA's Fermi Gamma-ray Space Telescope has identified the farthest gamma-ray blazars.
- Blazars are a type of galaxy whose intense emissions are powered by supersized black holes. They are among the brightest objects in the universe. The most distant of the newly discovered blazars started to emit their light when the universe was just 1.4 billion years old. Previously, the most distant blazars detected by Fermi emitted their light when the universe was about 2.1 billion years old.
- Blazars are similar to all active galaxies, acquiring energy from matter falling toward a central supermassive black hole. A small part of this infilling material becomes redirected into a pair of particle jets, which blast outward in opposite directions at nearly the speed of light.

2. NORTHWEST AFRICA 7635

- It is a 6.9-ounce (about 200gm) meteorite, discovered in Algeria in 2012, that has given scientists unprecedented insight into volcanic activity on Mars. The largest volcano in the solar system, Olympus Mons, is found on this planet. By analysing the chemical composition, "Northwest Africa 7635", scientists learnt that Mars had a single volcano that continuously erupted for 2 billion years.
- Martian volcanoes can grow to such enormous proportions because Mars, unlike Earth, doesn't have plate tectonics that constantly shuffle the surface. So a volcano, like the one that birthed NWA 7635, can plume — the process by which hot magma from the earth surfaces upward — for billions of years.

3. MISSION LUCY AND PSYCHE

- NASA has selected two missions that have the potential to open new windows on one of the earliest eras in the history of our solar system – a time less than 10 million years after the birth of our sun. The missions, known as Lucy and Psyche.
- **Lucy Mission:** Lucy will visit a target-rich environment of Jupiter's mysterious Trojan asteroids. Lucy, a robotic spacecraft, is scheduled to launch in October 2021. Lucy will build on the success of NASA's New Horizons mission to Pluto and the Kuiper Belt
- **Psyche Mission:** The Psyche mission will explore one of the most intriguing targets in the main asteroid belt – a giant metal asteroid, known as 16 Psyche, about three times farther away from the sun than is the Earth. This asteroid measures about 130 miles (210 kilometers) in diameter and, unlike most other asteroids that are rocky or icy bodies, is thought to be comprised mostly of metallic iron and nickel, similar to Earth's core.

4. SUNSPOTS

- They are darker, cooler areas on the surface of the sun in a region called the photosphere. Sunspots have temperatures of about 3,800 degrees K. They look dark only in comparison with the brighter and hotter regions of the photosphere around them. Sunspots can be very large, up to 50,000 kilometers in diameter.
- A new view of the dark, contorted centre of a sunspot that is nearly twice the diameter of the Earth, along with other invisible details of our Sun, has been unveiled by scientists. These results are an important expansion of the range of observations that can be used to probe the physics of our nearest star.

5. CASSINI

- Cassini is a sophisticated robotic spacecraft orbiting the ringed planet Saturn and studying the planet's system in detail. It is a joint endeavor of NASA, the European Space Agency (ESA) and the Italian space agency, Agenzia Spaziale Italiana (ASI). Cassini is the fourth space probe to visit Saturn and the first to enter orbit, and its mission is ongoing as of 2016. It has studied the planet and its many natural satellites since arriving there in 2004.
- It entered the orbit around Saturn in 2004, after an interplanetary voyage that included flybys of Earth, Venus, and Jupiter.At the end of 2004, Huygens separated from the orbiter and landed on Saturn's moon Titan on January 14, 2005. This was the first landing ever accomplished in the outer Solar System. It is towards the end of its epic voyage. In 2016, Cassini made the first close dive past the outer edges of Saturn's rings. These orbits, a series of 20, are called the F-ring orbits.

6. MYSTERY BEHIND BIRTH OF SATURN'S RINGS SOLVED

- The giant planets in our solar system have very diverse rings. Observations show that Saturn's rings are made of more than 95 per cent icy particles, while the rings of Uranus and Neptune are darker and may have higher rock content. Planetary rings that surround Saturn, Neptune and Uranus were formed four billion years ago when large objects passed very close to planets and got destroyed.
- **Kuiper Belt:** The Kuiper Belt is a disc-shaped region beyond Neptune that extends from about 30 to 55 astronomical units (compared to Earth which is one astronomical unit, or AU, from the Sun). The region is probably populated with hundreds of thousands of icy bodies larger than 100 km (62 miles) across and an estimated trillion or more comets. Dwarf planet Pluto may be the best known of the larger objects in the Kuiper Belt. Comets from the Kuiper Belt take less than 200 years to orbit the sun. Objects in the Kuiper Belt are presumed to be remnants from the formation of the solar system about 4.6 billion years ago. The first of these bodies, which astronomers call Kuiper Belt Objects (KBOs), came to light in 1992.

7. PUMPKIN STARS

- They are batch of rapidly spinning stars that produce X-rays at more than 100 times the peak levels ever seen from the sun. These stars spin so fast they've been squashed into pumpkin-like shapes.

8. BROWN DWARFS

- Brown dwarfs are objects which are too large to be called planets and too small to be stars. The mass of brown dwarfs is too small for full nuclear fusion of hydrogen to helium and the consequent release of energy to take place (as happens in stars). But they are usually significantly more massive than planets.
- Brown dwarfs were only a theoretical concept until they were first discovered in 1995. It is now thought that there might be as many brown dwarfs as there are stars. Brown dwarfs are very dim and cool compared with stars. The best hope for finding brown dwarfs is in using infrared telescopes, which can detect the heat from these objects even though they are too cool to radiate visible light.

9. MAGNETAR 1E 1613

- Magnetars are an extremely dense type of neutron star that can produce magnetic fields trillions of times stronger than our sun's. Neutron stars are formed when stars more massive than our sun explode as supernovae. NASA's Swift telescope has found a magnetar called 1E, located about 9,000 light years from Earth. This star possesses the most powerful magnetic fields in the universe — trillions of times that observed on the Sun — and can erupt with enormous amounts of energy.

10. ROSETTA MISSION

- Rosetta Mission was launched in 2004 by European Space Agency and arrived at Comet 67P/Churyumov-Gerasimenko in August, 2014, after a 10-year journey through the Solar System. Objective of Rosetta is to help understand the origin and evolution of the Solar System.
- It is the first mission to orbit and land on a comet. That makes Rosetta one of the most complex and ambitious missions ever undertaken. It will be the first spacecraft to witness, at close proximity, how a comet changes as it approaches the increasing intensity of the Sun's radiation.
- This comet was chosen as its composition reflects the composition of the pre-solar nebula out of which the Sun and the planets of the Solar System formed, more than 4.6 billion years ago. Therefore, an in-depth analysis of comet 67P/Churyumov-Gerasimenko by Rosetta and its lander (Philae) were to provide essential information to understand how the Solar System formed.
- Philae is a lander that accompanied the Rosetta spacecraft until it separated to land on comet. On 12 November 2014, Philae touched down on the comet, but it bounced when its anchoring harpoons failed to deploy and a thruster designed to hold the probe to the surface did not fire.

11. ASTEROID BENNU AND THE OSIRIS-REX MISSION

- Bennu is classified as a potentially hazardous asteroid. There is a small (1 in 2,700) chance that Bennu will hit Earth late in the 22nd century. If Bennu did hit Earth, it would release the energy equivalent of 1,450 megatons of TNT, creating an impact crater about 5 kilometres (about 3 miles) in diameter. That's over

70,000 times more energy than was released by the atomic bomb that fell on Hiroshima.

- OSIRIS-REx mission by NASA will be launched in Sept' 2016 with the goal of briefly landing on Bennu in 2018 and returning to Earth in 2023 with samples from its surface.

12. CERES

- Dwarf planet Ceres is the largest object in the asteroid belt between Mars and Jupiter and the only dwarf planet located in the inner solar system. NASA's Dawn Mission has identified permanently shadowed regions most of which likely have been cold enough to trap water ice for a billion years on the dwarf planet Ceres. When Dawn arrived in 2015, Ceres became the first dwarf planet to receive a visit from a spacecraft.

- Called an asteroid for many years, Ceres is so much bigger and so different from its rocky neighbors that scientists classified it as a dwarf planet in 2006. Even though Ceres comprises 25 percent of the asteroid belt's total mass, tiny Pluto is still 14 times more massive.

13. EUROPA

- Europa is one of more than 50 moons circling the Jupiter. NASA's Hubble Space Telescope has found evidence of possible water plumes. It is considered by NASA as a "top candidate" for life elsewhere in the solar system because it is believed to possess a massive, salty, subsurface ocean that is twice the size of Earth's.

14. NASA EXTREME ENVIRONMENT MISSION OPERATIONS (NEEMO) 21 EXPEDITION

- NEEMO-21 is NASA's 16-day mission, splashing down in the undersea Aquarius Reef Base in the Atlantic Ocean. The mission is to prepare for future deep space missions and the journey to Mars. Crew will explore tools and techniques being tested for future space exploration by living in simulated spacecraft conditions and conducting simulated spacewalks outside of their undersea habitat.

15. SUPERMOON

- It happens when a full moon is closest to Earth: Moon orbits our planet in an oval shape so sometimes it comes closer to us than at other times.To us on Earth, the moon appears 30 per cent brighter and 14 per cent bigger. Supermoon is not an astrological term. It's scientific name is perigee-syzygy. (As supermoon sounds more catchy, so, it is used by the media to describe our celestial neighbour when it gets up close). Astrologer Richard Nolle first came up with the term.

TELESCOPES

1. FIVE- HUNDRED-METER APERTURE SPHERICAL TELESCOPE (FAST)

- The largest radio telescope in the world was officially opened in September 2016 in China. At 500 meters, its diameter is 195 meters wider than the second largest telescope of its kind, the Arecibo Observatory in Puerto Rico. It is nicknamed

Tianyan. It will be used for observation of pulsars as well as exploration of interstellar molecules (related to how galaxies evolve) and interstellar communication signals (searching for intelligent extraterrestrial life).

- **Pulsars** are imploded cores of stars slightly larger than the Sun, which emit radiation that can be detected from earth, if your telescope is sensitive enough.

2. NASA-ISRO SYNTHETIC APERTURE RADAR (NISAR)

- It is a joint mission of NASA and ISRO to develop and launch a dual frequency synthetic aperture radar satellite. NISAR satellite is designed to observe and take measurements of some of the planet's most complex processes, including ecosystem disturbances, ice-sheet collapse, and natural hazards such as earthquakes, tsunamis, volcanoes and landslides.

3. GIANT METREWAVE RADIO TELESCOPE (GMRT):

- GMRT is an indigenous project set up by NCRA (National Centre for Radio Astrophysics), Pune. GMRT is a very versatile instrument for investigating a variety of radio astrophysical problems, ranging from nearby Solar system to the edge of observable Universe. Its important astrophysical objectives are: 1) To provide important constraints to the theories of formation of galaxies and clusters. 2) To search for and study rapidly-rotating Pulsars in our galaxy. Using GMRT and NASA's Chandra X-ray Observatory researchers observed a giant black hole and the merger of two enormous galaxy clusters.

4. JAMES WEBB SPACE TELESCOPE (JWST)

- It is the largest space telescope which is 100 times powerful than the Hubble Space Telescope. It will be a large infrared telescope with a 6.5-meter primary mirror. The telescope will be launched on an Ariane 5 rocket from French Guiana in 2018. JWST is an international collaboration between NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA). The space telescope will provide images of the first galaxies ever formed, and explore planets around distant stars.

5. ATACAMA LARGE MILLIMETER/SUBMILLIMETER ARRAY (ALMA)

- ALMA is anastronomical interferometer of radio telescopes in the Atacama Desert of northern Chile. It is an international partnership among Europe, USA, Canada, Japan, South Korea, Taiwan, and the Republic of Chile. Using ALMA, astronomers got a view of the water-snow line around V883 Ori star. This discovery can inform research on the formation of planets around a protostar - a star in the making.

CHAPTER – 12

MISCELLANEOUS RECENT DEVELOPMENTS

1. SUPERCONDUCTIVITY

- Superconductivity is a phenomenon observed in several metals and ceramic materials. When these materials are cooled to temperatures ranging from near absolute zero (0 degrees Kelvin, -273 degrees Celsius) to liquid nitrogen temperatures (77 K, -196 C), their electrical resistance drops down to zero. The temperature at which electrical resistance is zero is called the critical temperature (Tc) and this temperature is a characteristic of the material. So they can carry large amounts of electrical current for long periods of time without losing energy as heat. This property offers tremendous challenges and opportunities in the modern world.
- Magnetic-levitation trains can be made to "float" on strong superconducting magnets, virtually eliminating friction between the train and its tracks. In 2015, a Japanese Maglev test vehicle attained an incredible speed of 374 mph (603 kph).
- An area where superconductors can perform a life-saving function is in the field of biomagnetism, by helping in imaging the inside of human body.
- High-energy Large Hadron Collider (LHC), like the one at CERN, would never have been viable without superconductors. High-energy particle research hinges on being able to accelerate sub-atomic particles to nearly the speed of light. Superconductor magnets make this possible.
- Supercondutors are used in supercomputers.
- Superconductors have also found widespread applications in the military. HTSC (High temperature superconductors) devices are being used by the U.S. NAVY to detect mines and submarines.

2. BIOSIGNATURE

- A biosignature is any substance – such as an element, isotope, molecule, or phenomenon – that provides scientific evidence of past or present life in other planets satellites etc.
- These possible biosignatures include: molecular structures and isotopic compositions of carbon, nitrogen and hydrogen in organic matter; water etc.
- The presence of methane in the atmosphere of Mars indicates that there must be an active source on the planet

3. LHC & HIGGS BOSON

- One of the world's most expensive and complex experimental facilities to date is the Large Hadron Collider which is able to create Higgs bosons and other particles for observation and study.

- On 4 July 2012, it was announced that a previously unknown particle had been detected; physicists suspected at the time that it was the Higgs boson.
- By March 2013, the particle had been proven to be Higgs boson. More data is needed to know if the discovered particle exactly matches the predictions of the Standard Model, or whether, as predicted by some theories, multiple Higgs bosons exist. In the Standard Model, the Higgs particle is a boson with no spin, electric charge, or color charge. It is also very unstable, decaying into other particles almost immediately.
- The Higgs boson is named after Peter Higgs, one of six physicists who, in 1964, proposed the mechanism that suggested the existence of such a particle. In 2013 Peter Higgs and François Englert were awarded the Nobel Prize in Physics for their discovery.
- The Higgs boson is often called "the God particle" because it's said to be what caused the "Big Bang" that created our universe many years ago. Higgs boson is what joins everything and gives it matter.

4. GRAPHENE

- Graphene is one of the crystalline forms of carbon, alongside diamond, graphite, carbon nanotubes and fullerenes. In this material, carbon atoms are arranged in a regular hexagonal pattern. Graphene can be described as a one-atom thick layer of the layered mineral graphite.
- High-quality graphene is very strong, light, nearly transparent, and an excellent conductor of heat and electricity. Its interaction with other materials and with light, and its inherently two-dimensional nature, produce unique properties.
- Graphene is much more electrically conductive than copper or silver at room temperature. Researches demonstrated that graphene could facilitate the formation of a magnetic field under certain conditions. This development could potentially open the floodgates on graphene's use in computers, which use magnetic fields to store information on hard-drives.